SCIENTIFIC AMERICAN SUPPLEMENT No. 445

Scientific American Supplement, Vol. XVIII., No. 445.
Scientific American, established 1845.

NEW YORK, JULY 12, 1884.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

IMPROVED YACHT ENGINES.

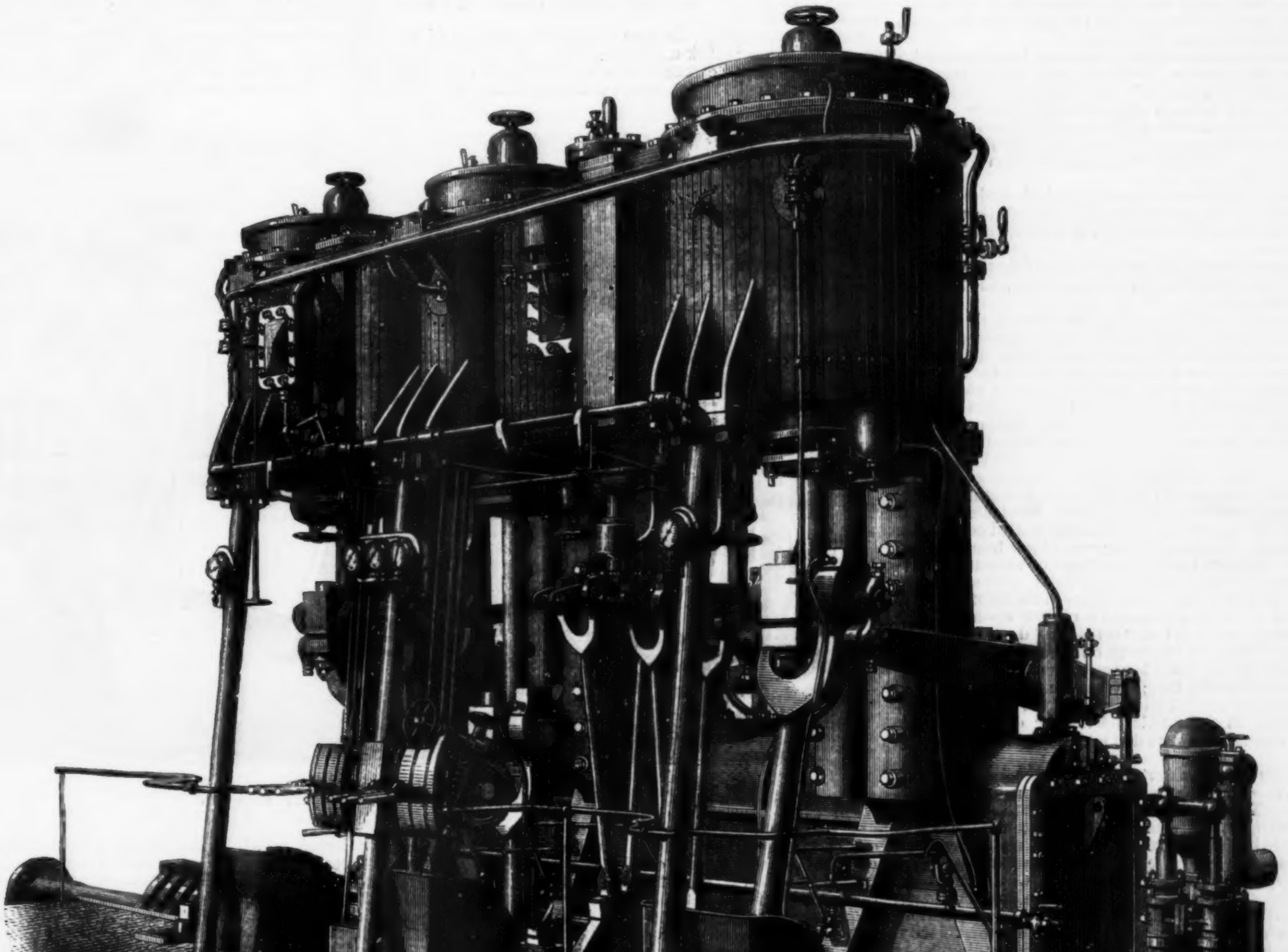
WE illustrate the engines of the steam yacht Lady Torfrida, which was constructed by Messrs Elder and Co. last year for Mr. William Pearce, the well known head of the firm. The Lady Torfrida is the most perfect vessel of her kind that has yet been built on the Clyde, while as a privately owned yacht there is probably no equal to her in British waters. Her construction, equipment, and fitting out were specially supervised by the owner. Built of steel, and measuring 200 ft. 8 in. long, 25 ft. 7 in. in breadth of beam, and 15 ft. 7 in. in depth, she has a tonnage of 620$\frac{4}{5}$. She has a clipper bow and handsome figure-head, and an elliptical stern, while she is schooner-rigged with very long, rakish masts. Forward she is fitted with a steam windlass by Harfield and Co., and aft she has a combined hand and steam steering gear, while on the bridge amidships there is a small steering wheel. All such deck fittings as are usually made of iron are made of manganese bronze. There is a large deck house, which is built of steel and covered with teak, and which incloses the engine and boiler space, the deck saloon, and the smoking room, in addition to which it affords entrances to the cabins forward and aft.

The engines of the Lady Torfrida are nominally of 175 horse-power; on trial they indicated 1,020 horse-power with a steam pressure of 110 lb. per square inch, and a vacuum of 28½ in. Their general design is shown by the perspective view. They are compound surface condensing, and have three inverted cylinders, viz., one high pressure, having a diameter of 24 in., and two low pressure, each of 34 in. in diameter, the length of stroke being 2 ft. 6 in. All the cylinders are steam jacketed. The high pressure cylinder, which is placed between the other two, has a valve of the equilibrium piston type, while the low pressure cylinders are fitted with ordinary slide valves. These valves are placed between the cylinders, and are worked by the usual eccentrics and link motion. The reversing of the engines is effected by means of a steam and hydraulic reversing engine made by Messrs. Brown Brothers, of Edinburgh. The crankshaft is of crucible cast steel, made by Messrs. Vickers, Sons, and Co. (Limited), and has three cranks. It is one solid forging, and has main bearings 10 in. in diameter and 10 in. long, while the crank-pin bearings are 9½ in. in diameter, and 10½ in. long. The tunnel and propeller shafts are also made of Messrs. Vickers' steel.

The surface condenser is placed at the back of the engines, the water being supplied to it by a reciprocating circulating pump worked by levers connected to the crosshead of one of the low-pressure engines—the air, feed, and bilge pumps being worked in a similar manner by the other low pressure engine. The surface condenser exposes 1,978 square ft. of surface, and the air pump, which is single acting, is 20 in. in diameter with 17 in. stroke, its discharging capacity being thus $\frac{1}{9.4}$ of the combined capacities of the two low pressure cylinders.

As is now almost the universal rule with Messrs. Elder and Co., the propeller is formed of solid manganese bronze, and it is 11 ft. in diameter with 14 ft. 6 in. pitch. The boiler for supplying steam to the engines is single ended and multitubular, and is made entirely of mild steel. It is 14 ft. 6 in. in diameter by 9 ft. long, and is fitted with three of Fox's patent corrugated furnaces, and brass tubes. The heating surface is 1,887 square feet, and the grate surface 77 square feet.

The accommodation of the yacht is spacious and well planned, while the decorations are most elaborate. The deck saloon, which has already been mentioned as forming part of the deck-house, is floored with various kinds of woods in parquetry, and the seats are cushioned in red morocco, a table being placed at the further end. The main saloon is both lofty and well proportioned. Its fittings and carvings, which have been designed in the style of the Italian Renaissance, are of dark mahogany, artistically grouped, and separated by gilt pilasters of a highly ornate character. The wall panels are covered with silk brocatelle in shades of terra-cotta and olive. Oil paintings on gold leather grounds representing ancient galleys conventionally treated are inserted in the center compartments, two on each side of the saloon. A pleasing effect is obtained by inclosing the side lights with elliptically-formed bays filled with lead-stained glass, which can be illuminated at night by a lamp placed inside, while two lamps of elegant design are suspended from the ceiling, which is paneled with mouldings run into octagonal and square forms and appropriately decorated. The saloon is very handsomely furnished, panels of hand painted tapestry in Louis XVI. style, fitted into the backs of the piano and writing table, forming one of the decorative features. The portieres, which were specially made in Paris, are of gray-blue satin, richly embroidered after the manner of old Persian work.



COMPOUND ENGINES OF THE STEAM YACHT LADY TORFRIDA.

Aft from the main saloon there are situated the ladies' cabin and the owner's room, the fittings and decorations of which are quite in keeping with those of the main saloon. From the latter there is a corridor, on either side of which are disposed the guests' state rooms, of which there are six forward and two aft. These state rooms are thoroughly ventilated, and furnished with a careful regard to comfort and convenience. The smoking room, already mentioned, is situated at the aft end of the deck house. It is also floored in parquetry, and is comfortably seated. The accommodation for the officers and crew is provided aft. For the former it includes a general mess room and a state room for each.

The Lady Torfrida is fitted throughout with every modern appliance for working convenience. The skylights, throughout, are of stained glass of rich coloring, all having appropriate designs.

On trial, the Lady Torfrida attained a maximum speed of 15 knots per hour, but she is usually run at a speed of about 13¼ knots.

WORK is proceeding rapidly with the great railway tunnel under the Mersey. The tunnel will be three and one-eighth miles in length.

WHAT IS FRICTION?

IT is now just a century since Coulomb first investigated the laws of friction, and half a century since Morin made at Paris the series of experiments which has rendered his name immortal; and yet it would hardly be too much to say that it is only at the present moment that we are beginning to arrive at a clear conception of what we mean by so familiar a term. In saying this we by no means wish to insinuate the slightest disparagement of the illustrious physicists we have named. The fault lies not with them, but with us. They had no desire—in the case of Gen. Morin, at least, we have his own authority for saying so—to impose their investigations on mankind as the last word of science, as absolutely and everywhere true, beyond as well as within the limits within which they were tried. They claimed to have laid the foundations and to have laid them aright, but they looked for other workmen to come forward and complete the edifice. Until very recently, however, such workmen have been less than few, their contributions more than scanty. To the past generation of engineers, immersed in the practical details of construction, and in the thousand and one cases of commercial manufacture, it was much easier to take Morin's results as they stood, and work by them, than to investigate the question any further for themselves. The same spirit of indifference has crept into our text-books, which quote Morin's results—with or without the courtesy of mentioning his name—as if they were no less rigidly true and general than the theory of gravitation itself. Yet it required the labors of a whole generation of astronomers to place Newton's theory beyond the reach of cavil; while the question of its possible limitation remains in dispute to the present day. In the sharpest contrast to this keen activity on the part of the votaries of science, the question of friction, whose practical importance it is scarcely possible to overrate, has been allowed to sink back, after the light flashed on it by the experiments we have referred to, into a hazy twilight, from which it is only beginning to emerge.

To illustrate the present state of the case, let us begin with the treatment of friction as it will be found in any standard book on "Applied Mechanics." First, we shall probably find a distinction drawn between statical friction, where the two surfaces are initially at rest, and dynamical friction, where they are already in motion. There we shall find a statement of what are called the "Laws of Friction" in something like the following terms:

1. Friction, whether statical or dynamical, varies directly as the force which presses the two surfaces together.
2. This force remaining the same, it is independent of the area in contact.
3. Under the same conditions the value of dynamical friction is much less than that of statical friction, but it is constant at all velocities.

To the statement of these laws may be added, in more elaborate and theoretical treatises—such as Moseley's "Engineering and Architecture"—a few words as to the limiting cases in which the laws cease to be exact, as, for instance, where the pressure approaches that of abrasion; and also of the state of things which prevails when the surfaces are fully lubricated with oil or grease, in which case Morin concludes that the friction, whatever the nature of the surfaces, approaches to a constant value at between 7 and 8 per cent. of the pressure. Then will follow tables, taken almost exclusively from Morin's results: (*a*) for plane surfaces at rest, sometimes dry, sometimes wet, sometimes lubricated; (*b*) for plane surfaces in motion, under similarly varied conditions; (*c*) for gudgeons or axles revolving upon their bearings, and more or less lubricated with ingredients of various descriptions. In collections of formulæ and rules, such as those of Molesworth and Rankine, these tables in an abridged form will be found to be the whole that is offered upon the subject. So deeply rooted is this "orthodox" doctrine, that we are acquainted with but one work on mechanics in which it is even hinted that the third law, as to dynamical friction, is by no means universally true; or that the friction of dry and lubricated surfaces are not phenomena of the same character. Yet skepticism on these points has long existed, but it is only within the last few years that it has broken out into open rebellion.

We are now able to assert positively two facts of which the compilers of our text-books have not had the slightest glimmering. The first is that what is called friction in the case of dry surfaces and what is called friction in the case of fully lubricated surfaces are not analogous phenomena, but totally different in every respect, observing different and even contrary laws, and having nothing whatever but an unfortunately chosen name to bind them together. The second is that dynamical friction is constant for similar surfaces only within comparatively narrow limits of velocity; and that beyond those limits it either increases or diminishes, as the speed varies, in a very unmistakable manner. It is evident that these two facts completely overthrow the sweet simplicity of the laws and tables of friction as they appear in our existing manuals.

It is worth while to dwell for a moment on the steps by which this change in our view of the question has been brought about. As long ago as 1852 the experiments made by Poiree and Bochet on shoe brakes and on the wheels of railway vehicles sliding on rails showed that the coefficient of friction diminished very much as the velocity increased. Between the limits of 906 feet and 3,600 feet per minute the coefficient of friction in the case of wheels sliding on rails diminished from 0·2 to 0·13. It is obvious that this is altogether contrary to the so-called law of dynamical friction, but it does not seem to have really awakened the sense of engineers to the question. There is nothing further chronicled until 1877, when Professor Kimball presented to the Royal Society a paper on the relations between friction and velocity. At ordinary speeds he found that the friction between pieces of pine wood diminished rapidly as the speed increased. Again, with a wrought iron shaft 1 inch in diameter, running in a cast iron bearing and well oiled, an increase of velocity from 6 feet to 100 feet per minute caused the coefficient of friction to fall as low as three-tenths of its first value. The same result was found with lower pressures, the pressure having in the first case been 77 pounds per square inch.

About the same time Professor B. H. Thurston was carrying out in America a number of experiments intended to test, under varying conditions of speed, temperature, pressure, etc., the friction of well lubricated journals. These were subsequently published in his well known book, "Friction and Lubrication." As to velocity, his conclusion was that the coefficient of friction at first *decreased* with increase of velocity, but after a certain point *increased*, and that the point of change is different at different pressures and temperatures. On the whole he considers that with well lubricated bearings, the friction increases with the velocity at all speeds exceeding 100 feet per minute, and that the rate of increase is approximately as the fifth root of the speed. Almost contemporaneously with these researches of Prof. Thurston, another American, Mr. George Westinghouse, was carrying out, in conjunction with Captain Douglas Galton, the magnificent series of experiments on the brake question which have since become classical under the name of the "Galton-Westinghouse Experiments."

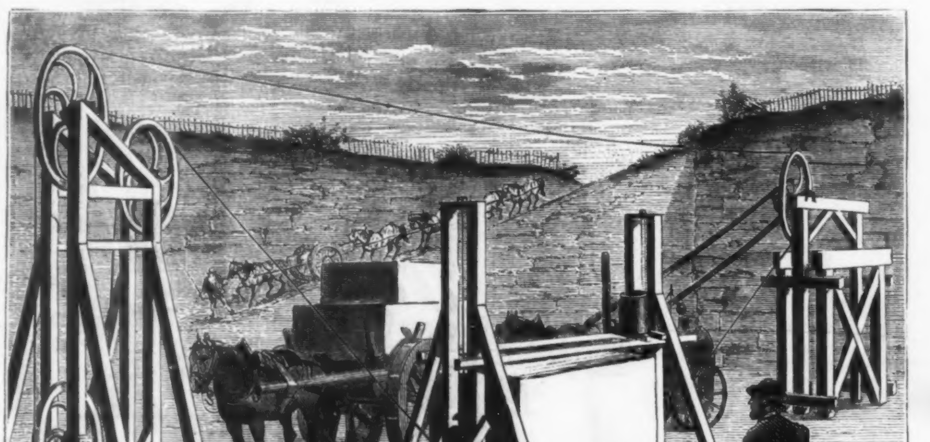
These threw much light upon the question of friction as between metals—generally cast iron and steel—which were rubbing over each other without lubrication, and at very high speeds. In every case they showed a remarkable diminution of friction as the speed increased. This result held throughout the whole range of the experiments, in which the speed varied from 400 feet to 5,300 feet per minute. It should be observed, however, that owing to the nature of the instruments used, the observations only lasted half a minute, and it was found that during that time the coefficient of friction continued to diminish. The ultimate values assumed by it under different circumstances cannot, therefore, be exactly known; but from the appearance of the curves, obtained by plotting the results, it is clear that the values for high speeds would still be much smaller than for low speeds. Professor Kennedy has deduced from the same experiments the result that the coefficient of friction was sensibly less at high than at low pressures, and that between the wheels and the rails—where the pressure was, no doubt, far greater than that on the brake blocks—the friction was not more than one-third of the amount found for the latter. This experiment is in accordance with Professor Thurston's results as to pressure, with ordinary velocities and loads; but the latter found that after a certain point a change took place, and further increase of pressure occasioned an increase in the friction. These results varied greatly under various circumstances, and they applied to lubricated journals, which, as we have seen, are really in altogether different circumstances from those of dry friction, as illustrated by the behavior of brake blocks.

Such was the state of the case when the Institution of Mechanical Engineers took up the question. Their progress in determining it has certainly been of the slowest; but they have lately issued a report which consolidates and advances our knowledge of the question in a remarkable degree. The experiments, which were conducted with great care by Mr. Beauchamp Tower, were first directed to ascertain the friction of journals under the best possible circumstance of lubrication; in other words, with a journal running in what may be described as an oil bath. By this it is not meant that the journal was absolutely buried in oil, but simply that its lower surface was always in contact with fresh oil, the upper surface being that on which the pressure rested. The results of these first experiments were very remarkable. In the first place it was found that the absolute friction, that is, the actual tangential force per square inch of bearing required to resist the tendency of the brass to go round with the journal, was much smaller than had ever been suggested before, falling in many cases as low as 0·001 of the pressure existing on the same area; secondly, it was found that this friction was nearly constant under all loads within ordinary working limits, and certainly it did not increase in direct proportion to the load, as writers on friction have always assumed. It only began to vary considerably when the pressure became excessive, and then the friction rose very rapidly and the bearing heated and seized. From this result it was naturally deduced that the friction of bearings in such circumstances is rather liquid than solid friction.

The theory of liquid friction is that it is independent of the pressure per unit of surface; is directly a dependent upon the extent of surface, and increases as the square of the velocity. In the case of these oil bath experiments the friction, as we have seen, is nearly independent of the pressure, and it was also found to increase with the velocity, at least with speeds beyond 150 feet per second. The question of its variation according to the surface in contact was not gone into. As regards other results, it appears that an increase in temperature caused a very marked diminution in the friction. For instance, with lard oil, the coefficient with the temperature at 120° F. was only one-third of what it was at 60° F. This is in accordance with previous results, but shows remarkably the advantage derived from keeping bearings warm. Again, it was discovered, though by accident, that the pressure existing in the film of oil at the top of the bearing, where the external pressure was highest, was very large; indeed, so great as to force the oil up through a small hole against a pressure of at least 200 pounds per square inch, this pressure being more than double the mean load on the horizontal sections of the journal.

Subsequent experiments with ordinary methods of lubrication were by no means so satisfactory. The methods for introducing the lubricant, which are found to answer in the case of railway vehicles, were found to fail altogether with this experimental journal. The cause is attributed, and no doubt rightly, to the absence of any shock or vibration in this case, such as goes on continually with a railway vehicle in motion. Fair results were, however, obtained by using an oily pad, pressed lightly against the under surface of the journal. Although the supply of oil was so small that the journal scarcely felt greasy, yet the bearing carried about 500 pounds per square inch; but in this case the results approximated much more closely to the laws of solid friction. The coefficient was approximately constant at about 1 per cent. of the load, and no very definite variations of friction with the speed could be observed. The lubricating of the journal by means of side grooves fed from a siphon lubricator was also successful, and gave somewhat the same results, as far as the constancy of the moment of friction is concerned, with those obtained by the oil bath; but the absolute amount of the friction was about four times as great. Now it will be observed that these results are practically coincident with those of Professor Thurston, and may be taken to establish the first of the two facts with which we started, viz., that the friction of thoroughly lubricated journals is a totally different phenomenon from what is commonly known as friction between dry surfaces. A complete reformation in the treatment of the subject by text-books, and in the tables supplied therein, becomes an imperative necessity.

It will be observed that none of the investigators we have mentioned commit themselves to any theory as to the real nature of friction, whether solid or liquid; they are content to record facts, and leave others to frame hypotheses from them. It is, however, a well known rule in the history of science, that the most fruitful progress in any department is made under the influence of some definite hypothesis, which it is the object of experimenters to confirm or disprove. Any physicist, therefore, who would put forward a good working hypothesis on the question of friction, or rather on the two questions of solid and liquid friction, would probably deserve well of the engineering profession and the world at large. There are plenty of problems besides those we have indicated, which such a theory should embrace. For instance, we know of a case some years ago where steel tubes were manufactured by pulling an annular ingot of steel, in the cold state, through an opening in a plate, much after the fashion of wire drawing on a large scale. In this process the finished tubes as they came out were generally perfectly cool, a result which probably few would have expected; on the other hand, one would occasionally appear which was sensibly warm if not hot. But the cause of this was well known by the workmen engaged in the manufacture; it could always be traced to the presence of a minute piece of grit or other substance which had got into the hole, and had drawn a fine scratch upon the surface of the steel as it passed through. This is surely a remarkable fact. We do not at all say that it is impossible or even difficult of explanation, but we may at least commend it to the attention of our readers; and it would not be hard to mention many others of the same kind. To attempt an answer to these problems would lead us far beyond our present limits, but taken in conjunction with the experiments here described they may at least justify us in putting forward the question placed at the head of this article, viz., What is friction?—*The Engineer*.



VIALATTE'S STONE SAW.

CONTINUOUS WIRE SAW.

THE object of Mr. Vialatte's recently invented saw, shown in the accompanying cut, is to saw stones of every nature, such as limestone, marble, and granite. Its principle is based upon the use of an endless cord composed of one or more strands of soft steel wire. This cord has a continuous motion in one direction and carries along with it quartzose sand. This latter alone effects the sawing, the wire only serving to transport it. The sand is moistened with water, in order to facilitate its flow at the bottom of the groove made in the stone and to prevent heating. The type shown in the cut in the one used in quarries and stone-yards. The apparatus is easily taken apart, and can therefore be moved about from one place to another without any trouble. It consists, in the first place, of two independent frames that face each other and support the two channeled pulleys over which the cable runs, and a third pulley that serves as a tautener and acts simply by its own weight. The frames may be separated from each other according to the length of the cable. Although their distance apart has no influence upon the work, it is well to remark that a long cable will not wear out so quickly as a short one of the same nature.

On each side of the stone there one two other frames to which are affixed wire guides, one at the entrance and the other at the exit of the cable. The object of these apparatus is to keep the wire perfectly straight, to isolate the stone from the vibrations of the motor, and consequently to obtain a perfectly straight cut. Each wire-guide consists of a small channeled pulley fixed between two uprights. A counterpoise causes them to exert the desired pressure upon the cable, and makes them descend in measure as the cutting proceeds.

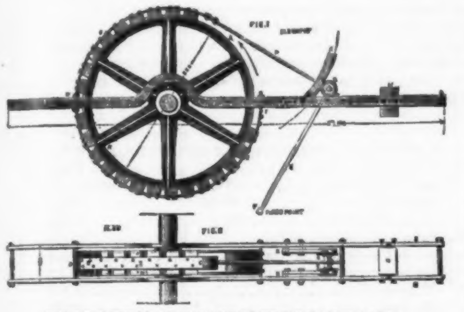
One considerable advantage possessed by this saw is that it may be used in quarries for cutting out blocks from the very banks themselves, this result being reached by sinking the wire-guides in holes drilled in advance.

This system of cable saw gives a daily product about four times greater than that that can be obtained with an ordinary blade.—*La Nature.*

DYNAMOMETER BRAKE.

THE modification of the Prony dynamometer brake, illustrated below, has been made by M. Ch. Bear, of Jemeppe-les-Liege, Belgium, with a view to the avoidance of the variation in the resistance offered by that brake. The idea involved is to make use of the oscillation of the brake strap and connections to increase or diminish the grip of the brake, so as to produce uniformity.

In our illustration, A is the brake pulley, B B are side



IMPROVED DYNAMOMETER BRAKE.

pieces forming a frame, C is the usual flexible metallic band fixed at D to the frame, and having one extremity held by a screw at E.

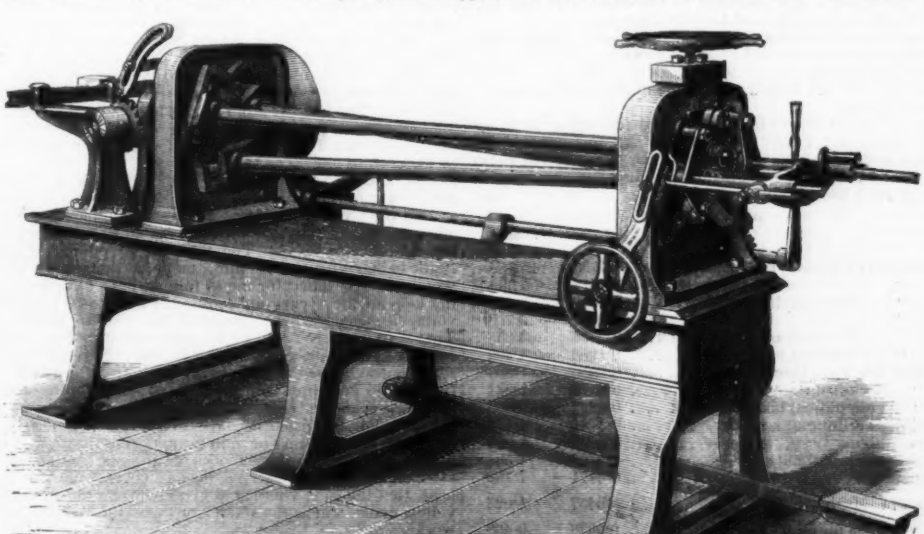
The other extremity is attached to the rod, F, which carries at G a crosshead and a pair of rollers, which roll on the eccentric path formed of two bars, H H, fixed to the frame, B, so that when the longer part of the frame descends the rollers run up the path, H, under the influence of the rod, K, pivoted at P, and thus increase the grip of the brake strap. When the frame rises the rollers, G, rolling on the lower part of the eccentric path, H, reduce the grip, and the lever at once descends.

With a determined weight, M therefore, corresponding to the power to be measured, the brake is self-adjusting. A very slight cause of error exists in the action of the rod, K, which is + or — according to the oscillation of the frame, but this has little effect.—*The Engineer.*

IMPROVED SCREW ROLLING PRESS.

THE accompanying illustration represents a screw forging machine—Fairbairn's patent—manufactured by Messrs Kendall and Gent, of Manchester, for rolling screw threads on bolt blanks or other suitable patterns on cylindrical pieces of iron or steel, such as twist drills, spindle ends, etc. The process of rolling threads on bolts is by no means a new one; but the inventor claims to be the first to produce screws by this process, without raising the threads beyond the diameter of the iron from which they are made, and also that he is able to give any number of revolutions to the screw under formation while it advances a given distance in a longitudinal direction, which not only gives the screw a finer finish, but also improves the quality of the iron. The machine consists of three revolving steel rollers having threads cut on their edges or peripheries, and these are brought together to press on a rod or bolt.

By pressing down the foot lever the bolt blank is drawn inward with its adjustable sliding support. On arriving at any fixed point the holder pushes against a lever which reverses the machine, and the screw is rolled in the opposite direction and delivered finished. All the wheels and shafts are made of steel. By this machine uniformity of pitch and shape of thread is secured with the smoothness of and at the same time greater strength than cut threads. Coupling screws of large diameter have been made for railway carriages on these machines, and have been produced with such accuracy that they have fitted nuts perfectly. To produce right and left hand threads no alteration in the position of the shafts is required, but merely a change of rollers. In the manufacture of screws with deep threads and wide pitch a considerable saving of time and material is effected by this process, as no scrap is made, as in the ordinary process, and the bolt blanks are consequently made proportionately shorter, the machine adding to the length of the screw what is usually cut away to leave the thread. The machine is also capable of making screws which cannot be cut at one operation, such as French rail screws, which are parallel along the top, but taper at the bottom of the threads. With regard to the question which might naturally be raised in connection with this method of manufacturing screws, as to whether they are not liable to be effected by differences in the temperature of the iron, it is pointed out by the inventor that in all previous attempts to roll screws the bolt had to be run through the rolls several times until brought down to a given size; but in this machine the bolts are finished at one run through the rolls, and every screw is taken direct from the bolt furnace, while in addition no attempt is made to roll two screws from the same rod at one heat, consequently any difference in temperature is so far eliminated as not to be sensible in the diameter and length of the nuts. —*The Engineer.*



FAIRBAIRN'S IMPROVED SCREW ROLLING MACHINE.

HOW TO MAKE PHOTOGRAPHS ON IVORINE.

IVORINE, it may be explained, is simply gelatine containing some white pigment, such as sulphate of baryta or oxide of zinc, together with a small proportion of glycerine, to prevent its becoming brittle when in thin sheets. This solution (or, rather, emulsion) is poured upon a leveled glass plate, allowed to set, and the plate is then reared up to dry in the same manner as ordinary gelatine plates. When the coating is dry, the film is stripped from the glass, and this is the ivorine of commerce. It is almost needless to say that the glass must have previously been waxed or rubbed over with powdered talc to prevent the film from adhering when dry.

Ivorine can be bought at most fancy stationers'. The following is the method we adopted: Some carbon prints were made upon collodionized glass in the same manner as if they were to be transferred to paper, except that they were not allowed to dry after being "alumed." The ivorine was then soaked in water until it became quite limp. It was now removed and laid upon the picture, the superfluous water being expelled with a very soft squeegee. The pictures were then allowed to dry, when they were stripped from the glass and trimmed round the edges with a pair of scissors. The pictures, it may be mentioned, were developed and the ivorine applied in the evening, and they were found to be perfectly dry by the following morning. Nothing can be simpler to work than this process, and the results produced are exceedingly pleasing. One or two things noticed during the experiments may, however, be mentioned, as they may be of some little assistance to those who may try the process. The ivorine must be made thoroughly and evenly soft, otherwise, when it is squeegeed on to the glass, it will "buckle up" and leave the picture. This we noticed particularly with one of our pieces which happened to be thicker at one end than at the other. When this piece was applied to the glass, the thickest end (although quite soft, was not so soft as the other) could not be kept down, but upon resoaking it all difficulty disappeared.

It is advisable not to soak the ivorine more than is necessary, as the longer it is soaked the longer it will, of course, take to dry. All the moisture it is possible to expel with the squeegee should be expelled; for, if any superfluous water be allowed to remain on the surface, it will cause the gelatine to continue swelling, and be liable to produce markings on the back of the finished picture from unequal drying.

In our first experiments we had some doubts as to whether, if the ivorine were simply softened in cold water, it would prove sufficiently adhesive to the carbon film; but our doubts were groundless, as by no possible means could the two films be separated when dry. However, it is quite possible that some samples of ivorine may be more insoluble than those we tried, and the mere treatment with cold water will not be sufficient. We therefore placed a sheet of it in tepid water before applying it to the picture; but this rendered it very difficult to manage, as the heat dissolved, or partially dissolved, both surfaces.

We then hit upon the following plan of softening or rather bringing about a state of partial solubility of one side only, which at once overcame all difficulty: The picture, after development and being treated with alum, was dried. A piece of the ivorine was now softened in cold water. The picture was placed in warm water, of about 110° Fahr., until the glass had acquired that temperature. The softened ivorine was then applied, and squeegeed down as before. By this method of procedure only that surface in contact with the picture is partially dissolved, instead of both. When this plan is adopted the ivorine should be cut somewhat larger than the picture, as, when it is placed upon the warm glass, it appears to contract to a considerable extent. It is well to put a few American clips round the edges of the plate to prevent any portion of the picture from leaving it before all parts are dry, which might cause markings.

It may be as well to mention that brown tones to our taste are much preferable on ivorine to purple. Those most satisfactory, to our mind, were printed in a warm chocolate pigment; but, of course, this is merely a matter of taste.—*Bri. Jour. of Phot.*

ON THE ECONOMIC APPLICATIONS OF SEAWEED.*

By EDWARD C. C. STANFORD, F.C.S.

SEAWEED AS FOOD.

IN this country little advance has been made in the use of the algæ as food. The algæ generally contain important nitrogenous constituents, and form nutritious articles of diet, but they have not been popular. We all like a "sniff of the briny," but we do not cultivate a taste for the internal consumption of our marine vegetables. We are equally guilty, however, in rejecting the majority of the fungi, so largely consumed as an important article of food on the Continent. The algæ are closely allied to these, but have the advantage of containing, as far as is known, no poisonous species. The algæ also contain a large proportion of salts, which, however, are easily removed, if desirable.

Ulva latissima, or green laver, and *Porphyra laciniata*, or pink laver, are occasionally used in soups. *Rhodomenia palmata*, or dulse, is still sold in the streets of Edinburgh and Glasgow. *Aliara esculenta*, or murlins, is also eaten in Ireland; some others are occasionally used, but as a general food the algæ are almost unknown. The sweetest species is the *Laminaria saccharina*, which is usually covered, when dry, with an efflorescence of mannite; a large quantity of this plant yielded me 7·47 per cent. of mannite. It appears to be a product of fermentation, and does not exist in the fresh plant. This plant is found only on sandy or gravelly shores.

The best known British species of the edible algæ is the *Chondrus crispus*, or Irish moss; this grows far down on the rocks, and is only uncovered at low spring tides. It is obtained mostly from the west coast of Ireland, and after being bleached by exposure to sun and rain, is largely exported to this country and to Germany. It is a gelatinous species, containing a principle known as carragheenin; it yielded me 63·7 per cent. of this substance.

The only other gelatinous British species is the *Gelideum corneum*; this is not very common, but it furnishes the import known as Japanese isinglass, of which it contains 50 per cent. This substance, known also as gelose, was first imported into France, from China, in 1856; it has great gelantinizing power, much higher than any other material. It is not nitrogenous, and contains carbon 42·8, hydrogen 5·8, oxygen 51·4.

The following table shows the value of these species in making jelly. The melting point of the jelly is also appended.

1,000 parts of water require of—

	Parts.	Proportion.	Melting point.
Gelose	4	1	90° Fahr.
Gelideum corneum	8	2	90° "
Irish moss (*Chondrus crispus*)	30	75	80° "
Isinglass	32	8	70° "
Gelatine	32	8	60° "
Carragheenin	36	9	70° "
Agar-agar (*Euchemia spinosa*)	60	15	90° "

It will be seen that gelose has eight times the gelatinizing power of isinglass and gelatine; but the melting point of the jelly is too high to melt quickly in the mouth, hence gelatine is still the favorite.

The carragheenin has evidently become altered by evaporation. Gelose jelly keeps well, the others soon get mouldy. Although not fit for jelly, gelose may be valuable in the arts as a substitute for gelatine, which it so much exceeds in gelatinizing power. I would specially suggest its use as a substitute for gelatine in the production of instantaneous photographs.

The *Euchemia spinosa*, or agar-agar, is an Australian alga, and another important gelatinous species. The algæ form a large article of food consumption in China and Japan. Some years ago I procured some of these samples; one was a dark green frond, and the other two were cut up from it, about the size of vermicelli; I append an analyses of these and of a sample of our own laminaria from Loch Eport in North Uist.

EDIBLE SEAWEEDS.—JAPAN.

	I.	II.	III.	IV.
Water	19·20	19·20	21·50	41·00
Volatile matter	59·50	48·20	49·70	32·29
Ash	21·30	32·60	28·80	26·71
ANALYSIS OF ASH.				
Soluble salts	74·18	74·85	61·81	72·50
Insoluble	9·84	5·21	33·68	18·69
Carbon	6·58	6·44	1·04	3·60
Silica	9·40	13·50	3·47	5·21
	100·00	100·00	100·00	100·00
ANALYSIS OF SALTS.				
Potash	31·90	16·20	40·95	28·26
Carbonate soda	14·61	14·41	5·35	5·00
Sulphuric acid	9·58	8·99	12·33	13·34
Chlorine	39·28	27·52	44·74	51·74
Iodine	0·3171	......	......	0·2946

No. I.—"This is a good average sample, worth to-day, in

* Abstract of a paper read before the Society of Arts, London, May, 1884.

this market, 11 taels, which at 6s. 6d., the average value of the tael, is 71s. 6d. per picul of 133 lb.; therefore one ton (16·75 piculs) would cost, in Shanghai, £57 4s. It can be cut finer, and then the price, if it is of the deep green which this is when it leaves me, would be about 14 taels per picul, or £72 10s. per ton."—*Extract from letters.*

The sample is green and evenly cut about as fine as vermicelli.

No. II.—"This is the worst sample I can find, worth 2 taels, which is £11 8s. per ton. The uncut leaf would be more valuable than this if of the color of No. I. It would fetch £16 per ton."—*Extract from same letters.*

This sample looks like the former deteriorated.

No. III.—This was apparently the uncut weed. It much resembles in color and appearance No. IV.

No. IV.—Laminaria, cut in Loch Eport, North Uist; color, dark green. Quotations by Mr. Frazer, Yokohama, September 18, 1868: Fine cut, £17 9s. 8d.; fine brown, £15 10s. 9d.; large green, £9 14s. 2d.—per ton. Specimens of No. IV. were sent out to Yokohama, but they did not take the market. It is remarkable that so high a price as 72s. 6d. per cwt. (or nearly 8d. per lb.) should be realized there for this seaweed for dietetic purposes.

The taste for marine vegetables must be acquired, but those who have eaten them often are said to become very fond of them; and I have known some gentlemen in the Highlands, no mean judges of diet, who consider a dish of dulse, boiled in milk, the best of all vegetables. There is no doubt that a valuable food is lost in entirely neglecting the algæ; but I shall show, presently, how much of this may be recovered in an available form.

SEAWEED AS MANURE.

This appears to me to be one of the worst applications of seaweed, and I do not think it has increased; farmers are beginning to find out that it seldom contains less than 80 per cent. of water, often more; and that for the actual manurial value in it, it may be very expensive if a long cartage is required. Four tons of water, at least, must be carted for every ton of dry manure, and when dried there is much additional expense, and it is very bulky. The dry weed contains an average of 2 per cent. of nitrogen, so that, as it is used, it contains less than ½ per cent. The chemical value is very little, except from the potash contained; but the mechanical value may be greater, as in covering root crops as a protection from frost, or where the soil is simply sand, and it binds it together. However, the cartage of water and the manufacture of soil are expensive amusements, and seaweed is not much used where there is high farming. It appears, also, where continually used alone, to impoverish the soil; it is like feeding a dog on butter. The residue of seaweed ash, or kelp waste, one ton of which is equal to forty tons of wet seaweed, and contains all the phosphates, is quite unsalable for manure in this country. It may be remarked, too, that in the wet climates of the west of Ireland and of Scotland, where it is mostly used, the application of water is quite a superfluous operation for the farmer.

Another application of seaweed, which I mentioned before, was the manufacture of paper. As far as I know, this has only been carried out in France, on one plant, the *Zostera marina*, or grass wrack, a material largely used in this country for stuffing mattresses and for packing light furniture. Some curious specimens of this plant, rolled up in little balls of fibre, were shown here at that meeting, as thrown up by the sea at Majorca and Minorca; and soon after it created a good deal of attention, having been proposed as a substitute for cotton; it contains little fiber, however. It grows in enormous fields, on sand banks, and is widely distributed, and is to be found in almost every ocean; it is a pure marine plant, with flowers, having nothing in common with the algæ except the habitat. It is often found on the shore perfectly bleached. All the algæ are cellular, and contain no fiber, but properly treated they make a tough, transparent paper, to which I shall have to allude presently.

THE MANUFACTURE OF KELP.

This crude substance, which, for many years, made the Highland estates so very valuable, was at first made as the principal source of carbonate of soda. At the beginning of this century it realized £20 to £22 per ton, and the Hebrides alone produced 20,000 tons per annum. The importation of barilla then began, and for the twenty-two years ending 1822, the average price was £10 10s. The duty was then taken off barilla, and the price of kelp fell to £8 10s.; and in 1823, on the removal of the salt duty, it fell to £3; and in 1831, to £2. It was used up to 1845 in the soap and glass factories of Glasgow, for the soda. Large chemical works were then existing in the island of Barra, built by General McNeill, for the manufacture of soap from kelp, and a very large sum of money was lost there. Two tall octagonal chimneys were still standing not long ago, but have now succumbed to the gales. In the mean time, soda was being largely made by the Le Blanc process, and superseded kelp, which was always a most expensive source, yielding only about 4 per cent., often less than 1 per cent.; it must have cost the soap makers what would be equal to £100 per ton for soda ash, the present price of which is £6.

The manufacture of iodine and potash salts then began to assume some importance, but the kelp required was not the same; that which contained the most soda containing the least iodine and potash. Chloride of potassium, the principal salt, was at one time worth £25 per ton. The discovery of the Stassfurt mineral speedily reduced this price to about a third, and the further discovery of bromine in this mineral also reduced the price of that element from 38s. per lb. to 1s. 3d., its present price. The amount of bromine in kelp is small, about a tenth of the iodine, and not now worth extracting. Large quantities are now produced in Germany and America. More recently, the manufacture of iodine from the caliche in Peru has attained large proportions, and has so far reduced the price of that article as to make its manufacture from kelp unremunerative. In a paper, compiled for the British Association, published in 1877, I estimated the then total production of iodine in Great Britain and France at 2,000 kegs of 1 cwt. each, and the future production of Peru at 6,000 kegs; an estimate which is now being rapidly realized.

In 1882, the amount of iodine exported from Peru was 205,800 kilos, or 4,116 kegs, divided as follows:

To London	120,900 kilos.
" Hamburg	62,100 "
" New York	22,800 "
	205,800 "

The present annual output is estimated at 300,000 kilos, or 6,000 kegs.

On the other hand, the present manufacture of Great Britain and France is less than 1,000 kegs, the production of France being now reduced to almost nothing, and the kelp sold as manure.

I append an abstract of a table in that paper, showing the imports of kelp into Glasgow, to which city or its district the manufacture of British iodine has always been confined.

The prices given are the average prices for the year; higher than the maximum, but not lower than the minimum, have been reached. It is remarkable that we are now coming back to exactly the price of 1841, forty-three years ago, and also exactly to the price of twenty-two years ago, when my first paper was written. Potash salts, however, were then three times the present price.

IMPORTS OF KELP INTO CLYDE.

Five years, 1841 to 1845.

Tons of kelp, 1,887 in 1844 to 6,086 in 1845; average, 3,133. Price of iodine per lb., 4s. 8d. in 1842 to 31s. 1d. in 1845; average 11s. 9d.

Ten years, 1846 to 1855.

Tons of kelp, 3,627 in 1846 to 11,421 to 1850; average, 3,627. Price of iodine per lb., 8s. 8d. in 1851 to 21s. 3d. in 1846; average, 12s. 11d.

Ten years, 1856 to 1865.

Tons of kelp, 6,349 in 1856 to 14,028 in 1863; average, 9,730. Price of iodine per lb., 5s. in 1863 to 13s. 8d. in 1856; average, 8s. 10d.

Ten years, 1866 to 1875.

Tons of kelp, 8,116 in 1868 to 10,923 to 1874; average, 9,187. Price of iodine per lb., 10s. in 1866 to 34s. in 1872; average, 15s. 11d.

Seven years, 1876 to 1883.

Tons of kelp, about 6,000 to 8,000; average, about 7,000. Price of iodine, 5s. in 1883 to 15s. 6d. in 1879; average, about 10s. 2d.

Total average kelp import, 1841 to 1883 (42 years), 6,750 tons. Average price of iodine per lb., 12s.

So that the present price is only about 40 per cent. of the average value. The great fluctuation in the price, and the small bulk of the article in proportion to its value, and the limited production, have led to great speculation, and I have no doubt a few kegs might still be found here and there in London which were bought some years ago at a pretty high price, and are still waiting the improbability of a turn in the market.

The amount of iodine in sea water is so minute that it is extremely difficult to detect by ordinary tests; by evaporating down two portions of sea water, filtered and unfiltered, each over 14 gallons, and by employing a delicate color test, I have succeeded in estimating it. The sea water was collected carefully in the Atlantic, west of the island of Tyree. I found in 1,000,000 grs. measure (14·2857 gallons) of unfiltered sea water, 0·003572, or 1 in 280,000,000; in 1,000,000 grs. measure of filtered sea water 0·003442, or 1 in 291,000,000. The unfiltered water might be expected to contain more iodine from minute algæ in suspension, although it appeared clear. Kortstoffer, who estimated it in the Mediterranean, puts it at 1 part in 50,000,000. Bromine is easily detected; sea water generally contains about 6 parts in 100,000, and of chlorine about 2 per cent. Professor Dittmar, who has been working out the sea water samples of the Challenger expedition, has discovered a remarkable relation between this element and that of the chlorine, which he has kindly communicated to me. He finds the relation in the great number of samples examined (77) to be constant in the proportion of 0·340 bromine to 100 chlorine. He finds the average amount of chlorine to be 1·9 per cent., or 19,000 parts in 1,000,000, and of bromine 0·00646 per cent., or 64·6 parts in 1,000,000, or 18,422 times as much as my mean result for the iodine.

The Woodal Spa has been long known to be very rich in iodine and bromine; a recent analysis by Wright giving of chlorine 11,113·73 parts per million, bromine 49·7 parts per million, iodine 5·21 parts per million. Here the relation of bromine to chlorine is 0·44 to 100, and the iodine about a tenth of the bromine; in sea water the proportion of iodine is a very minute fraction of this. Examination of the brine and the mother liquor from the salt mines of Cheshire failed to detect iodine. The algæ possess the power of assimilating the iodine to about ten times the extent of the bromine. I append estimates of iodine in a number of algæ; those of the Laminaria and Fuci are the average of a great number of specimens collected at different times of the year, and all around Great Britain and Ireland, the Channel Islands, and the Isle of Man, and including Orkney and Shetland, Iceland, Denmark, and Norway. I append also estimates of the iodine in several of the giant algæ in the Falkland Islands, for which I am indebted to Governor Kerr and Mr. F. G. Cobb, of the Falkland Islands Company.

These gigantic species are seen in this country for the first time in the fresh state, and little is known about them. The macrocystis is said to grow to a length of 1,500 ft., or over a quarter of a mile in length. It grows in 10 fathoms water in Stanley harbor.

The *d' Urvillea* forms stems branched like trees 12 ft. or 14 ft. long, and a foot in diameter. All these weeds are thrown up in enormous quantities on the shores of the Falkland Islands, and along the Straits of Magellan, making it difficult for a boat to approach them.

DRY WEEDS.

	Per cent.	Pounds. per ton.
Laminaria Digitata, tangle stem	0·4535	10·158
" " Bardarrig frond	0·2946	6·599
" Stenophylla stem	0·4028	9·021
" " frond	0·4777	10·702
" Saccharina, sugar wrack	0·2794	6·258
" Bulbosa	0·1966	4·403
Fucus Serratus, black wrack	0·0856	1·807
" Nodosus, knobbed wrack	0·0572	1·281
" Vesiculosus, bladder wrack	0·0297	0·665
Halidrys Siliquosa, sea oak	0·2131	4·773
Hymanthalia Lorea, sea laces	0·0892	1·998
Rhodomenia Palmata, dulse	0·7120	1·594
Japanese edible seaweed	0·3171	7·102
Zostera Marina {Nat. order Zosteraceæ}	0·0457	1·023
Rhodomela pinnastriodes	0·0378	0·468
Chordaria flagelliformis	0·2810	6·294
Chorda filum, sea twine	0·1200	2·688
Chondrus crispus, Irish moss	Trace	—
Enteromorpha compressa, sea grass	Nil	—
Gelideum corneum, Japan	Trace	—
" " Cornwall	"	—
Euchemia spinosa (agar-agar)	Nil	—

FALKLAND ISLANDS GIANT ALGÆ.

	Per cent.	pounds. per ton.
D'Urvillæa utilis, No. 1	0·0075	0·179
" " No. 2	Trace	—
Lessonia No. 1	0·0284	0·636
" No. 2	0·0181	0·405
Macrocystis Pyrifera	0·0308	0·690

In the foregoing table the Laminariæ and the Fuci are the kelp-producing species.

It is remarkable that the three gelatinous species, *Chondrus*, *Gelideum*, and *Euchemia* contain little or no iodine.

It is noticeable, too, that the *Enteromorpha*, or sea grass, a plant which retains, when dry, a very strong odor of the sea, contains no iodine.

It is also remarkable that the giant algæ contain so little iodine, growing outside the influence of the Gulf Stream, which, rightly or wrongly, has been supposed to be the iodine carrier. It is a curious fact that there are certain seeds, supposed by the natives to grow on the tangle, and called "tangle nuts." A specimen here from Tyree is evidently the seed of a leguminous American tree, brought over by the Gulf Stream.

It is probable that all animal substances from the sea contain iodine; its presence has been long known in cod-liver oil, a substance supposed to be rich in it, and to owe most of its valuable medicinal property to it, but I found, after investigating a good many various specimens of this oil, that the amount is infinitesimal. The liver itself contains double as much; oysters, especially the Portuguese variety, have also been said to contain a good deal. The following are my results:

		Per cent.
Cod-liver oil, average of six specimens		0·000322
Cod-liver, fresh		0·000817
Salt cod fish	48·5 per cent. water	0·000255
Salt ling fish	50·25 " "	0·000150
Fresh cod fish	80·7 " "	0·000160
Scotch herring, salt		0·000650
Scotch herring, brine		0·000120
Oysters, Portuguese		0·000040
Whale oil		0·000100
Seal oil		0·000050

There are two distinct and well-defined varieties of kelp. Cut weed or black-wrack kelp, and drift weed or red ware kelp. Cut weed kelp is the old soda-producing variety, and is made from the three *Fuci*, *Fucus vesiculosus*, *F. nodosus*, and *F. serratus;* these grow on the rocks in the order named, the latter being the most submerged and containing the most iodine, though all contain but little. The plants are cut at low tide, floated ashore, dried and burnt; the weed does not soften much by rain, and it can always be obtained in the fine natural harbors of the West of Scotland and Ireland. This kelp, burnt into a dense fused slag, contained the most carbonate of soda, and was that variety which employed so many poor crofters and cottars, and enriched so many Highland lairds. It is now worthless, and the Fuci which hang from the rocks at low water in luxurious festoons in these lochs, are now entirely unutilized. I have seen 10,000 tons of this weed cut in a single loch, in a few weeks of summer.

The drift kelp is made from two varieties of red weeds, or Laminaria, the *L. Digitata*, and the *L. Stenophylla*, the former known as tangle; both are always submerged, and are torn up by the violent gales so common on the west coast; both are sometimes cut in Ireland with long hooks under water from boats. These plants, especially the latter, suffer very much from rain, and are often, after drying, almost valueless; but if well saved, contain ten times as much iodine as the Fuci.

This is the only kelp now used for making iodine, and it ought to be burnt into a loose ash; but although they employ a different material, we have to deal with the same people, and they still insist on raking it into a molten slag, with iron clauts, at great extra trouble, so much so that the men of the family are obliged to do this part of the work, under the erroneous impression that it will weigh heavier, thus mistaking specific gravity for weight; the fact being that they drive off more than half the iodine, and a great deal of the salts, spending several extra laborious hours in reducing the value to a half. It may be asked why we allow it? An incident which occurred to me may answer that question.

Some years ago, when I had to take a large quantity of black-wrack kelp in North Uist, it was made to enable the people to pay their rents, and could not then be given up, though it has been since. I tried hard to get some improvement made in the direction of burning the weed at a lower temperature. The people were assembled in great numbers, and the sheriff eloquently harangued them in Gaelic for me. Their objections were threefold: it would not yield so much, it would not be so good, and it would take too long. The late Sir John P. Orde, the proprietor, and his factor were present, and it was agreed at last that the most experienced kelper and myself should try the experiment, each to have a certain quantity of weed weighed out to him, and each to burn it his own way. As I expected, my lot was finished first. The yield was 25 per cent. greater, and the product was also, weight for weight, 25 per cent. more valuable. Any one can understand this double advantage of ash *versus* slag. The old man, my opponent, on the result being explained to him, made a remark in Gaelic, which was translated for me as follows: "I have been making kelp for fifty years and more, and am I to be taught by a young Sassenach with no beard on his face to speak of?" That was the only result of the experiment. How could I explain to him, especially in Gaelic, the difference between specific gravity and weight, to say nothing of quality? As they would not improve process, the work had to be stopped, and their evidence before the Royal Commission shows how much they have missed it. We took away their clauts, but it was no use; landing once in the middle of the night, I came upon a group hard at work with new irons, raking off the salts, and making themselves hideous, for so intense is the heat, that the soda volatilized gives a strong monochromatic yellow flame, which does not improve the beauty of the workers.

To show that this extraordinary idea still prevails, I quote the following from a daily paper, referring to the island of Tyree this year:

"The men attending the kilns used to turn over the burning mass with iron 'clauts,' but about two years ago the company forbade the use of the 'clauts,' and the kelp is simply reduced to ashes instead of a hard substance. It may be bet-

ter fitted for manufacture in this state, but it is also evident that it will take more of it to make a ton than by the old process."

It has one advantage for them; being on the sandy shore, or shingle, it enables them to rake in, and embody with the fused kelp a quantity of sand and stones. We sometimes get a block of granite thinly veneered with kelp from our Irish friends, to remind us, I presume, of their national wrongs, and take a slight revenge.

The great heat involves the additional disadvantage that the carbon reduces the sulphates to sulphides, which involve considerable expenditure of oil of vitriol to decompose them, so that sulphur thus deposited is one of the by-products of the lixiviation of kelp. We are, therefore, compelled to reverse the ordinary process, and manufacture sulphur from sulphuric acid.

The usual yield of kelp from 100 tons of wet seaweed is 5 tons, and as only half of this is soluble, 2½ tons forms the total valuable product of the labor of cutting, carrying, drying, and burning 100 tons of wet seaweed; the burner, in many parts, does not receive more than £2 per ton, sometimes less, so that all this labor is done for 2s. per ton of weed. When it is also remembered that bad weather often reduces this payment to nothing, it is easy to understand that this occupation is soon given up where any other employment can be obtained. Moreover, the weed is dried in a climate where a native comes up to you with the rain pouring off his hat and nose, and outrages your sense of sight by informing you, if he knows "the English," that it is "a wee misty." The large mass of material to be dealt with, the stormy character of the coasts, the constant moisture of the climate, all tend to still further reduce the quantity obtained. Even with favorable conditions, the yield is only 5 per cent., which is quite inadequate to afford profit either to the maker or to the lixiviator.

These evils were fully pointed out in my former paper, and a method was then suggested by which several new products could be obtained, and the whole of the iodine secured. I proposed to submit the seaweed to destructive distillation in iron retorts, thus obtaining a loose, porous charcoal, which retains the salts and the iodine; ammonia, acetic acid, and tar were obtained from the distillate. In looking over the tables published in my former papers, some of the diagrams of which are once more on the wall, I notice that the amount of iodine lost in kelp was much underestimated; much too low a figure having been taken for the produce of iodine. The amount of kelp then made was 10,000 tons in this country, and 24,000 in France; and I estimated the loss of iodine, in this country alone, at 50,000 lb. annually; it really was about three times that amount, or 150,000 lb., worth, even at the present low price, £37,500, a sum in excess of the whole value of the additional new products proposed to be recovered.

The Duke of Argyll was the first to see the value of the improvement suggested, and the new process was first carried out in his island of Tyree, in 1863, where works were erected for the purpose; soon afterward works were also erected in North Uist, under an arrangement with the late proprietor, Sir John P. Orde; and more recently in Ireland.

In some respects, Tyree was the best place that could have been selected, in others, the worst. The wildness of its shores, and its numerous outlying rocks, make it the deposit of much drift weed. The inaccessibility and the great difficulty of landing heavy machinery, etc., made the erection of works extremely difficult. The factor calculated that 30,000 tons were used annually for manure, and that four times that quantity was lost. Our calculations were based on recovering 16,000 tons of this, and if even that quantity could have been obtained, the works there would have had a very great success, and turned out more iodine than all the other Highland shores put together. It is impossible, however, to estimate the amount of seaweed thrown up in a storm, and the sea has an awkward habit of calling again, and removing a good deal of it, or covering it over with sand. This seaweed is also much injured by rain, which soon washes out the salts and iodine. It is a nitrogenous substance, and is quickly devoured by maggots, which become flies, and the material, like some other riches, speedily takes to itself wings and flies away, so that when once I carted a large quantity to the works for experiment, some knowing ones observed that the Sassenach had taken a great deal of trouble to put in the material, but it would not give him any kind of pains to put it out, as it would leave him of its own accord. I may add that it did not; there is nothing so offensive as rotten seaweed, but I had preserved the weed with chloride of calcium. In the winter the long sea rods are thrown up, and these when properly stacked bear a good deal of exposure. There was much difficulty in getting the people to collect these at first, for it was a new thing and they did not believe in it. They soon found out, however, that it affords winter employment for what they call "a lairge sma' family," and which, to do them credit, most of them possess, as children can work at it. It consists simply in stacking the tangle out of reach of the tide. This work has been going on ever since 1863, and none is lost that can be secured. The works in Tyree and in North Uist are still continued, to the great advantage of the people. For the latter the tangle is also collected in South Uist and shipped to Loch Eport. Both these islands also yielded large quantities of black wrack kelp, which is now entirely given up.

The works were lighted with the gas obtained by distillation, but after the gas has passed through all the purifiers, it still burns with a strong monochromatic yellow flame. The ammonia obtained is all used as manure for the farm; for whatever other business you follow in these outer islands, you must be a farmer, to feed your horses, etc. The tar is used for the roof of the works; and I may state here, that after great experience of large roofs, many of which have been blown away, I prefer a lattice girder low felt roof. No one who has not witnessed a winter gale in one of the Hebrides can form an idea of it. We find it advisable to raise the walls two feet above the girders on each side. I would also mention here that there is no building so efficient or suitable for the damp climate of these outer islands as concrete. The shingle of the shore is always there as the bulk of the material, and cement only has to be sent out. A vessel loaded with quicklime, anchored off one of these islands in a gale, is not a happy or a safe possession, and I know from experience that it does not contribute to the sweetness of sleep.

Iron retorts, heated by coal or peat, were at first used, but these were superseded by brick ovens, which are now employed without fuel. The tangle swells in the retort, and produces a charcoal of great porosity, from which the salts are easily washed out, and there are no sulphides. The residual charcoal is a very efficient decolorizer and deodorizer, but has never been largely used for these purposes. I shall mention presently an application of it.

The following analysis shows the comparison of this charcoal with that from bone. It does not in any way approach the composition of that from wood:

	Seaweed.	Bone.
Carbon*	52·54	11·77
Phosphates	10·92	77·70
Calcium carbonate	15·56	8·43
Calcium sulphate	—	0·85
Magnesium carbonate	11·34	—
Alkaline salt	5·70	1·09
Silica, etc.	3·94	0·66
	100·00	100·00
*Containing nitrogen		
Containing ammonia	1·75	1·5

My experience in the use of peat may be worth recording. I found it give a very fair red heat; we cut and stacked about 600 tons a year of good quality in North Uist; it costs 2s. 6d. per ton, and I do not think that it can be obtained for less. There was no royalty or rent, and the bog was close to the works. It required three times the quantity compared with coal, which greatly increases cost of firing. There is this peculiarity about peat, that where a large supply is required its cost increases with the quantity collected, because a larger area must be worked.

The winter tangle forms but a small part of the seaweed used for kelp. In the spring and autumn large quantities of Bardarrig or tangle top come ashcre, and this is the substance most difficult to deal with. It is ruined for kelp making by rain, and it will not repay cartage to a long distance. Even washing about in the sea spoils it. To work it by my process would require a large number of small works, which is out of the question, so that it is still mostly made into kelp in the old way, with all its attendant evils. It is this substance which I propose now mainly to deal with. I am convinced that no process will deal effectually with it unless it will afford the means of removing it to central works, say at Glasgow, involving a cost for carriage equal probably to the cost of the weed, doubling in fact its first cost. There are two ways of removing it, either wet or air dry. I prefer the latter, although I have proved that it can be perfectly well kept in a silo, a specimen so kept for several months having reached me perfectly good, and still containing 83·8 per cent. moisture; and it has been also proved that such a covering of earth as that used for potatoes is an available silo. Most of this material can, however, be got air dry, if, as soon as obtained, it is put in a rick and thatched över, a good deal of it being lost at present while they are waiting for enough to burn into kelp, which cannot be made in a small quantity, and for a way they have for putting it in small staks to get damp again, because they object to burning it too dry. Twenty thousand tons of this dry material could easily be got in Ireland alone. Four hundred thousand tons of the black wrack was the usual annual collection in the Hebrides in former years, now all unutilized, so that there is ample material if use can be found for it. It is a well known fact that the Fuci grow better when regularly cut.

We are not, of course, limited to Ireland and the Highlands, as any demand for the raw material would offer up new and extensive sources of supply.

The difference between kelp making and distillation in retorts, is shown by the following actual experiment on eight tons of tangle. Four tons were burnt with great care into kelp, and four tons were carbonized in a retort with the following results:

	Cwt.	Per cent.
Kelp produced	15	18·7
Char "	30	37·5
	Salts, cwt.	**Iodine, lb.**
Produce of char	8·77	29·25
" kelp	6·57	13·27
Loss in kelp	2·10	15·98
" per ton of tangle	0·53	4·00

As a rule the kelp does not contain anything like this. The presence of sand particularly, adds much to the volatility of the iodine.

A rich sample of seaweed ash, exposed in a platinum capsule over an ordinary Bunsen burner for twenty-four hours, will not retain a trace of iodine.

The sand in kelp is either shell sand, which is mostly carbonate of lime, or flint sand, which is silica; both are highly prejudicial, as the following experiment shows—100 grains of a rich seaweed ash was in each case heated for ten hours over an ordinary Bunsen burner.

	Per cent.	pounds per ton.
The ash contained of iodine	0·8930	20
The ash after heating ten hours	0·4911	11
The ash with 50 per cent. limestone	0·3572	8
The ash with 50 per cent. sand	0·2235	5

NEW PROCESS.

The salts made from kelp at present are as follows, taking an average on 20,000 tons:

	Per ton.	
Muriate (95 per cent. potassium chloride)	5	cwt.
Sulphate (75 " potassium sulphate)	1·8	"
Kelp salt (sodium chloride, containing carbonate = 8 per cent. alkali	3·8	"
	10·6	

Iodine, 12½ lb. per ton.

I found, in the first instance, that these salts could be easily extracted from the seaweed, by simple maceration in cold water; the amount so removed from air dry Laminaria is pretty regularly about one-third of the weight, or 33 per cent., of which 20 to 22 per cent. are mineral salts, and the balance consists of dextrine, mannite, and extractive matter; leaving two-thirds of the plant, or 66 per cent., for further treatment, apparently unaltered.

This residue contains a peculiar new substance, to which I have given the name of Algin, and the cellulose, the whole plant being thus utilized.

The comparison between the two processes will therefore be as follows, on 100 tons of air dry Laminaria:

KELP PROCESS.

Per cent. utilized, 18.

Kelp, 18 tons.	Salts, 9 tons. Iodine, 270 lb.	Residuals—Kelp waste 18 tons, valueless.

CHAR PROCESS.

Per cent. utilized, 36.

Char, 36 tons.	Salts, 15 tons. Iodine, 690 lb.	Residuals—Charcoal 36 tons, tar, and ammonia.

WET PROCESS.

Per cent. utilized, 70.

Water extract, 33 tons.	Salts, 20 tons. Iodine, 600 lb.	Residuals—Algin 20 tons, cellulose 15 tons, dextrine, etc.

Showing that the last process has the first advantage of taking out more salts and iodine from the weed than any other; and these, even at present prices, are sufficient to recoup all the expense of carriage and working. Moreover, in the two prior processes, the residuals are those of the first product; in the last these are from the weed itself.

The water extract is carbonized, and the salts extracted. I append analyses of these; they differ from the kelp in containing no sulphides, and in containing calcium and magnesium salts.

AIR DRY (LAMINARIA STENOPHYLLA).

21 per cent. salts.

	Per cent.
Calcium sulphate	1·93
Potassium sulphate	9·72
Potassium chloride	31·97
Sodium chloride	48·67
Sodium iodide	1·79
Sodium hydrate	0·13
Magnesium chloride	5·74
	99·95

RESIDUAL WEED (LAMINARIA STENOPHYLLA).

2·32 per cent. salts.

	Per cent.
Potassium sulphate	35·27
Potassium chloride	6·72
Potassium carbonate	5·00
Sodium carbonate	49·97
Sodium iodide	2·63
	99·49

It will be seen that 90 per cent. of all the salts are thus removed, and much of those that remain are products of decomposition. These salts are obtained by the carbonization of the water extract. This is not necessary, and may not be advisable, the salts can be fished out during evaporation. I append analysis of a 2 cwt. sample so fished:

Calcium sulphate	1·18
Potassium sulphate	14·20
Potassium chloride	27·81
Sodium chloride	55·11
Sodium iodide	1·69
	99·99

Iodine 32 lb. per ton.

Also of the mother liquor 54° Twad. evaporated:

Potassium sulphate	16·35
Potassium chloride	17·48
Sodium chloride	54·98
Sodium carbonate	5·13
Sodium iodide	5·27
Water	0·79
	99·91

Iodine 100 lb. per ton.

We now come to the treatment of the residual weed. If the long fronds of the Laminaria stenophylla be observed after exposure to rain, a tumid appearance will be noticed, and sacs of fluid are formed from the endosmosis of the water through the membrane, dissolving a peculiar glutinous principle. If the sacs be cut, a neutral glairy colorless fluid escapes. It may often be seen partially evaporated on the frond as a colorless jelly. This substance, which is then insoluble in water, is the remarkable body to which I have given the name of Algin. The natural liquid itself is miscible with water, but coagulated by alcohol and by mineral acids. It contains calcium, magnesium, and sodium, in combination with a new acid which I call alginic acid. When this natural liquid is evaporated to dryness, it becomes insoluble in water, but it is very soluble in alkalies. This new substanee is so abundant in the plant that, on maceration for twenty-four hours in sodium carbonate in the cold, the plant is completely disintegrated. The mass thus obtained is a glutinous mass of great viscosity, and difficult to deal with on that account. It consists of the cellulose of the plant mixed with sodium alginate. The cells are so small that they pass through many filters, but by cautiously heating it the mass can be filtered through a rough linen filter bag, the cellulose being left behind, and after the algin is removed this is easily pressed.

The solution contains dextrine and other extractive matter, and it is then precipitated by hydrochloric or sulphuric acid; the alginic acid precipitates in light gray albuminous flocks, and is easily washed and pressed, in an ordinary wooden screw press. A filter press made for me by Messrs. Johnson and Company answers perfectly well for this operation, but not so well for the preceding. It forms a compact cake, resembling new cheese, and has only to be stored in an ordinary cool drying room, where it can be kept any length of time. If desired, by adding a little bleach during the precipitation, it can be obtained perfectly white. The algin can be sent out in this state; it is only necessary to dissolve it in sodium carbonate in the cold for use. If, however, it be sent out as sodium alginate, it must be dissolved to saturation in sodium carbonate, the carbonic acid is disengaged, and sodium alginate is formed. If potassium or ammonium carbonate be used, the alginates of potassium or ammonium are formed, which are similar to the soda-salt. The bicarbonates of these alkalies may also be used; but the caustic alkalies are not such good solvents.

The sodium alginate forms a thick solution at 2 per cent., it cannot be made above 5 per cent., and will not pour at that strength. Its viscosity is extraordinary. It was compared with well-boiled wheat starch, and with gum arabic in an ordinary viscometer tube; the strengths employed were as follows; it was found impossible to make the algin run at all over the strength employed:

			Seconds.
Gum arabic solution,	25 per cent.	took	75 = 1 in 3
Wheat starch "	1·5 "	"	25 = 1 in 8
Algin "	1·25 "	"	140 = 1 in 112

So that the algin has 14 times the viscosity of starch, and 37 times that of gum arabic.

I append analyses of two samples of commercial sodium alginate of average composition:

	No. 1.		No. 2.	
Water	17·13		19·30	
Organic matter	59·97		58·125	
Carbonate soda	18·32	P.C. ash 22·90	17·78	P. C. ash 22·575
Neutral salts	2·98		2·77	
Insoluble ash	1·60		2·025	
	100·00		100·00	
Dry algin	67·58		65·50	
Soda (Na_2O)	10·71		10·40	
Per ct. of Na_2O	15·85		15·87	

Showing that, excluding the water, salts, and ash, the composition is uniform.

The solution may be alkaline, or neutral, or acid, according to the degree of saturation; if alkaline, it may be made distinctly acid by the addition of hydrochloric acid, but any excess at once coagulates it; a 2 per cent. solution becomes semi-solid on this addition.

The evaporation is effected in a similar manner to that of gelatine, in thin layers on trays or slate shelves, in a drying room with a current of air, or on revolving cylinders heated internally by steam; high temperatures must be avoided. The solution keeps well. Thus obtained, the sodium alginate presents the form of thin, almost colorless, sheets, resembling gelatine, but very flexible. It has several remarkable properties which distinguish it from all other known substances.

Algin or sodium alginate in solution is precipitated or coagulated by alcohol, ethylic and methylic, acetone, and collodion (but not by ether), by acid hydrochloric, sulphoindigotic, nitric, sulphuric, sulphurous, phosphoric, citric, tartaric, lactic, oxalic, and picric; salts of cobalt, copper, platinum, nickel, silver, bismuth, antimony, zinc, cadmium, aluminum, chromium, uranium, barium, calcium, strontium, and tin chloride and bichloride; mercury pernitrate and protonitrate; iron sulphate (white), and iron perchloride (brown); lead acetate and basic acetate; lime water and baryta water.

The solution is not precipitated nor coagulated by alkalies and salts of alkalies, including lithium, alkaline silicates, potass bichromate (not coagulated by boiling), and chromate; sodium stannate, succinate, biborate, and tungstate; magnesium and manganese salts, starch, glycerine, ether, cane sugar, amylic alcohol, boracic acid, acetic, carbolic, tannic, butyric, benzoic, gallic, pyrogallic, arsenious, and succinic acids; potass ferrocyanide, mercury iodide, ferricyanide, and permanganate; bromine, iodine, and chlorine water; molybdate ammonia, tartar emetic, and peroxide hydrogen. It does not precipitate the ordinary alkaloids.

It is distinguished from albumen, which it most resembles, by not coagulating on heating, and from gelose by not gelatinizing on cooling, by containing nitrogen, and by dissolving in weak alkaline solution, and being insoluble in boiling water.

From gelatine, by giving no reaction with tannin; from starch, by giving no color with iodine, from dextrine, gum arabic, tragacanth, and pectin, by its insolubility in dilute alcohol and dilute mineral acids.

It is remarkable that it precipitates the salts of the alkaline earths, with the exception of magnesium, and also most of the metals, but it gives no precipitate with mercury bichloride nor potassium silicate.

It has a strong rotary power on polarized light; Mr. Tatlock estimated it for me as having a specific rotary power of 86·5° on Laurent's polariscope. This again fixes its position among animal bodies, gelatine, and albumen, and not among such vegetable products as pectin, which is neutral.

Alginic acid is insoluble in cold water, very slightly in boiling. It is insoluble in alcohol, ether, and glycerine. The proportion of soda ash used is one-tenth of the weight of the weed, and the cake of alginic acid obtained is usually about the same weight as the weed. The quantity of dry alginic acid is given below:

	Laminaria Digitata. Stem.	Laminaria Digitata. Frond.
Water	37·04	44·0
Alginic acid	21·00	17·35
Cellulose	28·20	11·00

	Laminaria Stenophylla. Stem.	Laminaria Stenophylla. Frond.	Laminaria Bulbosa.	Fucus vesiculus.
Water	34 5	40·02	43·28	40·10
Alginic acid	25 7	24·06	17·95	12·22
Cellulose	11·27	15·06	11·15	.....

FALKLAND ISLANDS GIANT ALGÆ.

Nos.	1	2	3	4	5
Alginic acid	11·21	10 09	5·56	7·44	3·34
Cellulose	8·13	7·25	3·50	12·95	9·68

The three gelatinous algæ, already referred to, contain no algin.

The cellulose in the tangle is higher than in any other weed, the outside of the stem being rather fibrous. I append also analyses of the ash of three varieties of cellulose dry, unbleached, to show the trace of iodine still retained:

	Laminaria Digitata.	Laminaria Stenophylla.	Fucus vesiculus.
Yield of char	38·36	36·41	44·62
Soluble	11·08	5 27	11·06
Carbon	12·73	14·27	15·93
Ash	14·55	16·87	17·63
Iodine	0·12	0·06	0·05
On air dry plant about	0·012	0·006	0·005

The new process may be tabulated as follows:

		Per cent.
Extracted by water—		
Salts	20	
Sugar, mucilage, etc	10	
	—	30
Extracted by sodium carbonate—		
Algin	20	
Dextrine, etc.	10	
	—	30
Cellulose		10
Moisture		30
		100

Of these, I have accounted for the salts, the algin, and the cellulose, leaving the mucilage, dextrine, and sugar for further investigation.

It is not necessary to extract the salts first with water; it comes to the same thing to act on the seaweed at once with soda ash, and to recover the salts by evaporation of the solution, after the alginic acid has been precipitated. In this case chloride of calcium or of aluminum may be employed, the alginate of calcium or aluminum being precipitated. With either salt the alginate is thrown down instead of rising to the surface of the liquid, and the cakes are more compact and easily pressed. In addition to the cheapness with which it can be procured in almost any quantity, as a by-product in alkali works, now all thrown away, the calcium chloride has the advantage of throwing down the sulphates in the salts, and decomposing them into chlorides, so that the salts consist of chlorides of potassium and sodium, which are easily separated, and do not require the tedious and expensive processes necessary in the lixiviation of kelp. The same remark applies to aluminum chloride, which can be cheaply obtained by dissolving bauxite in hydrochloric acid. Either salt can be decomposed by hydrochloric acid, and the calcium or aluminum chlorides recovered; or the salts can be decomposed by sodium carbonate. The calcium alginate, when dry, is very like bone, as the dry alginic acid is like horn. The aluminum alginate is soluble in caustic soda, forming a neutral solution, and giving, on evaporation, a substance like algin, but harder and making a stiffer finish; it is also soluble in ammonia, the salt becoming an insoluble varnish on evaporation. The alginates of copper (blue), nickel (green), cobalt (red), chromium (green), and zinc are all soluble in ammonia, and form beautiful colored insoluble films on evaporation. So also do the alginates of platinum, uranium (yellow), and cadmium. The latter is exceedingly soluble in ammonia. The alginate of chromium is also soluble in cold water, and it is deposited on boiling the solution, becoming then insoluble.

With bichrome, algin acts as gelatine, the mixture becoming insoluble under the influence of light. The silver alginate darkens very rapidly under exposure to light, and suggests applications in photography. Algin forms a singular compound with shellac, both being soluble in ammonia; it is a tough sheet, which can be rendered quite insoluble by passing it through an acid bath.

COMMERCIAL APPLICATION OF ALGIN, OR SODIUM ALGINATE.

For sizing fabrics.—A soluble gum of considerable elasticity and flexibility is a great desideratum; so also is a soluble substitute for albumen which can be easily rendered insoluble and used as a mordant. As a finish, algin has the advantage over starch that it fills the cloth better, that it is tougher and more elastic, that it is transparent when dry, and that it is not acted upon by acids. It imparts to the goods a thick clothy elastic feeling, without the stiffness imparted by starch. It has the additional advantage, which no other gum possesses, of becoming insoluble in the presence of a dilute acid, which decomposes starch or dextrine. No other gum has anything like the viscosity in solution, and therefore none will go as far in making up the solution or cover such a large surface. Lime-water, salts of calcium, barium, and various metallic salts can be employed for rendering the coating insoluble. If greater stiffness be required, the algin can be mixed with gum arabic, starch, dextrine, gelatine, albumen, or glue in any proportion.

The alginate of alumina, in caustic soda, is a stiff dressing, and in the crude, unbleached state will be a cheap dressing for dark materials; and in the colorless state for finer fabrics. The ammoniated alginate of alumina can be used to give a glossy surface, which is quite insoluble after drying.

As to its use as a mordant in dyeing, I quote from Mr. John Christie, of J. Orr Ewing & Co., to whom I am indebted for the fine specimens of Turkey red dyeing exhibited, some of which are finished and mordanted with this new substance instead of cow dung: "There is another application of the alginate of soda that occurred to me might be of some interest, namely, in the fixing of mordants, such as alumina or iron, upon cotton fibre. I find, so far as I have gone with the experiments, very encouraging results. I believe a very large application will be found for the alginate of soda as a dunging substitute. The mordants, when precipitated, seem to have full dyeing power, the results indicating that this substance is capable of taking the place of cow dung, as used in print and dye-works; also as a dunging substitute it will rank with arseniates, phosphate, and silicate of soda, and a number of other salts, which are now largely used for the precipitation of mordants previous to the dyeing of cotton fabrics and yarns."

AS AN ARTICLE OF FOOD.

Algin contains—carbon, 44·39; hydrogen, 5·47; nitrogen, 3·77; oxygen, 46·37; or about the same amount of nitrogen found in Dutch cheese. It has a slight pleasant marine taste, easily overcome if objected to, and may form a useful addition to the kitchen for thickening soups and puddings. It appears specially adapted to replace gum arabic in the manufacture of jujubes and lozenges. To make it into jelly requires addition of gelose or gelatine, or admixture of lemon juice.

It will be useful for some pharmaceutical purposes, as for emulsion of oils, as an excipient for pills, and for fining of spirits.

FOR BOILER INCRUSTATION.

The sodium alginate has a remarkable effect in resolving and preventing the incrustation of boilers. My friend, Mr. Spiller, who introduced the first and one of the best fluids for this purpose, first suggested this application. He found it to precipitate the lime in a state in which it could be easily blown off. Further experience has fully corroborated his opinion. The solution is pumped in with the feed water, in the proportion of 1 lb. to every 1,000 gallons. Where hard waters are a necessity, the saving of fuel is considerable.

FOR COVERING BOILERS.

The seaweed charcoal, in conjunction with algin, is used for this purpose, and has been largely applied under the name of "carbon cement." It is nearly all charcoal, 3 per cent. of the algin being sufficient to make it cohere. Charcoal is known to be the best solid non-conductor of heat, and in this way its application to steam boilers has been made practicable. It forms a cool, light, and efficient covering.

ALGIC CELLULOSE.

This substance bleaches easily, and under pressure becomes very hard, and can be turned and polished with facility. It also makes a good paper, tough and transparent, but with no fiber. Alone, or mixed with algin and linseed oil, or shellac, it may be used as a non-conductor of electricity, where a cheap material is required.

Although there is still a small portion of the plant not accounted for, which will, I hope, also soon be worked out, I think enough has been discovered to justify the following conclusions:

1. The only way to effectually utilize seaweed is to import it in the raw state.

2. By following the wet process, the additional cost is fully made up by the greatly increased amount of iodine and salts obtained from the water solution, leaving two-thirds of the plant for further treatment.

3. That by extracting from this the algin and the cellulose we utilize the whole plant, and obtain two new products of considerable commercial importance.

4. That the process is extremely simple, and requires no extravagant plant; nor do operations on the large scale present any serious practical difficulties.

5. That the new substance, algin, has very remarkable properties, which may find many applications not yet known, when it can be put on the market.

6. That the demand for such a substance in fixing and mordanting fabrics alone is enormous.

Our annual export of textile manufactures and yarns is valued at £40,000,000, or more than half the value of our total exports; and a large portion of this requires some dressing material to fit it for the market. We import about £200,000 worth of gum arabic, a good deal of which is used for this purpose; and the war in the Soudan is raising its price, and making it scarce.

7. That the supply of raw material is almost unlimited. Seaweed damaged by rain is equally available for the manufacture of algin.

I will only add that I bring forward this process with some confidence, as the result of a quarter of a century's scientific work, and an almost equally long practical experience—an experience gained in a wide and wild school. I am satisfied, whether it may be given to me to carry it out or not to the extent it should be, it will become the process of the near future. It immediately possesses the advantage of obtaining known marketable products of considerable value, and it bids fair to open up a new industry which may become one of large extent, supplying, as it will, new products for which there is an absolute want. On the other hand, the importance of attaching a marketable value to seaweed can scarcely be overrated. No Royal Commission will give the crofters and cottars on the shores of the Hebrides and the west of Ireland anything like the satisfaction that the offer of £1 per ton for all the seaweed they could gather would. In all these places the sea quest might soon become more important than the land question. Moreover, a shipping trade in the raw material itself is a great benefit to the outlying islands where it is obtained; it necessitates cartage, it tends to the improvement of roads and harbors, it improves communication by bringing steamers and necessarily brings the people closer to civilization and the great centers of industry. This is especially the case where the expenditure of every thousand pounds on the raw material means the expenditure of about as much on carriage. I have reason to know that the lairds of all these shores would not be entirely dissatisfied with such a result. We should all share in the satisfaction of knowing that one more waste product had been effectually utilized.

DISCUSSION.

Mr. E. M. Holmes said the thanks of the whole country were due to Mr. Stanford, for suggesting what might prove a very extensive industry, and one which might benefit the poorer classes of the population in districts where at present many of them were nearly starving. He had recently, at Swanage, noticed cows and donkeys on the beach eating the seaweed thrown up on the shore, and it occurred to him that seaweed might perhaps be utilized as food for animals. When they considered the immense amount of seaweed sold in China and Japan, it was astonishing that so small a use was made of it as food in this country. Laver (*Porphyra vulgaris*) was used to some extent in Devonshire, and it was by no means disagreeable in taste. Mannite, which was another product mentioned by Mr. Stanford, was principally obtained from Italy; but some algæ contained it in considerable quantity, and he saw no reason why it should not be utilized. With regard to the use of seaweed as manure, he knew it was constantly so employed in the Channel Islands, and we certainly obtained our earliest vegetables from those islands. He thought it was an error to regard the manurial value of seaweed merely from the point of view of the salts which they contained. Gardeners distinguished between what they called live and dead soil, live soil being that in which the decomposition of either animal or vegetable matter was going on, and this process apparently had an influence in causing changes of a chemical nature in the soil which promoted the growth of plants; it could, therefore, be reasonably supposed that the algæ might be more beneficial in the fresh state than when dried. He understood Mr. Stanford to say that the algæ from deeper water contained more iodine than those which grew nearer the shore, but in the table given, the largest amount was from the *Laminaria stenophylla*, which always grew higher on the shore than the *Laminaria digitata*. Another interesting point was that some of the gigantic algæ contained less iodine than the common Laminarias of our own shores. In the "Flora Antarctica," published by Dr. Hooker some years ago, it was stated that Dr. Stenhouse had analyzed these algæ, and had found in them a large quantity of iodine, and in one of them a considerable quantity of mannite; but probably so much was not known at that time about iodine, and no doubt Mr. Stanford's analyses were the more correct. But the interesting questions remained, where the iodine came from, and whether, as he believed Mr. Stanford thought, it came from the warm waters of the Gulf of Mexico. He should like to ask Mr. Stanford to what he attributed the strong odor of sea water possessed by the *Enteromorpha*, as he stated that it contained no iodine. To show the rapid growth of the Fuci, he might refer to a statement in Dr. Landsborough's little book on marine algæ, that at one place in Scotland, where the rocks had been scraped quite bare, the algæ grew to a length of six ft. in six months. The idea of keeping seaweeds in a silo seemed a very excellent one, because under certain circumstances, as in wet weather, it was almost impossible to keep it without losing the salts. With regard to the use of algin for pharmaceutical purposes, it had already been employed for emulsifying cod-liver oil, and was found very superior to other agents, especially as it contained a small quantity of iodine. Some time ago he read that some parts of the coast of Mauritius were covered at certain times with immense quantities of foam, caused by mucilage apparently derived from Laminaria; and it occurred to him that perhaps the algæ might be employed for producing a head on beer, in preference to quillaia bark, which he understood was now used for that purpose, and which must be of a somewhat irritating character, from containing saponin; whereas the algin would certainly be of a harmless character. It occurred to him, from the insolubility of the salts of alginic acid, that it might perhaps be useful for waterproofing purposes. He should also like to ask whether textile fabrics became less

combustible from its use. With regard to its substitution for gum arabic, he might say that it was almost impossible of late years to obtain this gum of good quality. That which they now obtained made a mucilage more like that of white of egg than that from good gum. The bean found with the sea wrack was one which was found in the West Indies, commonly called the ass's-eye bean (*Mucuna urens*).

Mr. T. Christy said he had brought with him some *Eucheuma speciosa* from the western shore of Australia; and among several seaweeds which he had put into commercial use, none gave such excellent results in dyeing and the preparation of mordants. He had had several requests from France to procure further supplies, but though he held out every inducement to the traders on the west coast of Australia to forward this seaweed, he had not succeeded in getting any more. Mr. Greth, in making some experiments with it, and also on some Japanese seaweed, found that it took up 500 times its weight of water, and as a sizing material there was nothing equal to it. He had also tried it in several preparations for damp walls, and found it most effectual, both with plaster, lime, and brick walls. Mr. Greth was still working at this subject in Berlin. The use of the algæ in combination with shellac was of great importance, as it prevented the extreme brittleness which arose from the use of shellac alone. It was largely used for this purpose in France, where they were very particular as to the class of seaweed, and next to that from Australia the weed from Singapore met with most favor. He had lately, however, received some *E. Spinosa* from Borneo, which was even superior to that from Singapore. There was an immense field for the use of seaweed, if a regular supply could be depended upon of these qualities.

Mr. Lloyd said every one who had passed a heap of seaweed must have noticed the disagreeable smell which came from it, showing that it was most liable to decomposition, and this was the root of the difficulty of dealing with it as food; besides which, few if any people knew how to cook it. In Wales it was largely used fried in oil, and he believed it was also used in London to some extent boiled like greens. He was much surprised to hear that seaweed had been kept in a silo, and retained 80 per cent. of moisture, knowing its liability to decompose, and the immense difficulty which farmers had found in keeping grass with only 75 per cent. of moisture; it would be interesting to know what changes had taken place, and whether the preservation was due to the formation of some acid, or to the presence of salt in considerable quantities. Looking to the precipitating power of one of the products Mr. Stanford had obtained, it occurred to him that possibly it might be useful in the purification of sewage, at any rate in the initial operation of throwing down the solid matter.

Mr. Stanford said that algin had been tried in photography, but there was one disadvantage about it, that the silver coagulum was not such a strong one as any of the others. What he had suggested for photography was gelose; it made a good emulsion, and dry plates had been worked with it. With regard to the preservation in the silo, he could only say that the seaweed had been kept for six months, and it was of a kind very difficult to keep, containing, when dry, about 35 per cent. of salts, and very liable to rot. It was put into a well-built silo, and after six months was taken out apparently unaltered. He could not say what was the exact change which had taken place, nor did he think this was as yet ascertained in the case of hay or grass. He did not, however, think the salt had anything to do with it; it was a description of seaweed which, if air got to it at all, became full of bacteria, and rotted very quickly. He might also say that it had been noticed years ago that when a large quantity of this substance was kept under pressure, that which was kept underneath kept very well. He understood Mr. Christy to be referring to the *agar-agar* as the seaweed from Australia which had given so much satisfaction. He had always drawn the line between these three gelatine-producing species and any other seaweed. Some years ago he investigated all the species he could get hold of, and could not find gelatine in any but the *Gelideum corneum* and the *Chondrus crispus*, and it was somewhat remarkable that neither those nor the Australian *agar-agar* contained either iodine or algin. With regard to Mr. Cross' remarks, he thought that gentleman had already shown that cellulose was sufficiently difficult to investigate without going into any nitrogenous substances. He had placed algin among the albumens and gelatines, and though he had made a great number of experiments on the decomposition products of it, he had not yet arrived at any satisfactory conclusions such as he could lay before a scientific society. This substance had not been known quite so long as gelatine and albumen, and yet the chemistry of both those substances was in almost as unsatisfactory a state as that of algin. He had not tried whether textile fabrics treated with this material would be less combustible, but probably they would be, from its containing soda. As to the odor of the *Enteromorpha compressa*, he had not the slightest idea what it came from, any more than he had what caused the odor of the sea; which again would form an interesting subject for investigation to any young chemist who liked to devote his lifetime to it. As to the important question of the deep-sea algæ, and the *stenophylla*, which he had given as containing more iodine than the deep-sea tangle, although it grew higher up, the reason was, that the *stenophylla* varied very much in composition; there was no plant he was acquainted with which varied so much in the amount of iodine it contained. In fact, all the seaweeds varied very much according to the time of year, the age of the plant, and other circumstances. The *Laminaria digitata*, both the stem and the frond, almost always contained a definite amount of iodine, and though in this case the *stenophylla* had come out with the largest percentage, it might easily have been the other way. With regard to the use of seaweed as food, it was a remarkable fact that in Japan they were used with a large amount of salts in them—as much as 30 per cent. when they were sent into the market. He considered that in isolating the algin we obtained the whole food value and the whole of the nitrogen of the plant. He was much obliged to Mr. Holmes for the diagrams and specimens he had lent him, and would draw special attention to a specimen of giant algæ from the Falkland Islands, one of which was supposed to be the longest plant in the world, growing sometimes to the length of 1,500 feet.

CARNIVOROUS plants that lie in wait for and entrap unsuspecting insects have long been known. Now Prof. Baird sounds a warning against a voracious fish-eating plant. The queer feature of the story is that this bladderwort has hitherto been carefully introduced into the Government's carp ponds as food for the fish, nobody surmising that it makes the fish its own food. The carp might well complain of misplaced confidence against their protectors

BOULIER'S UNIVERSAL PYROMETER.

WE may, to a certain extent, appreciate the difficulties that any given problem presents from the number of different principles that are called upon to solve it.

The pyrometer, or measurer of high temperatures, certainly stands in the first rank of difficult problems, although several apparatus of this kind have been devised that have been used with more or less success. These are the gas pyrometers, and that of Wedgwood, founded upon the con-

FIG. 1.—GENERAL VIEW OF BOULIER'S PYROMETER.

traction of clay, that of Lamy, founded upon the laws of dissociation, the calorimetric pyrometer, founded upon the calorific capacities or specific heats of bodies, the electric pyrometer of Siemens, the radiating one of Tremeschini, etc. Finally, there is still another class that we may style circulating pyrometers, and to this belongs the one that we shall now describe. A very interesting study published in the *Portefeuille economique des Machines* tells us that the principle upon which the Messrs. Boulier Bros.' circulating pyrometer is founded was patented, for the first time, in 1879 by Mr. Saintignon. This principle consists in causing a cur-

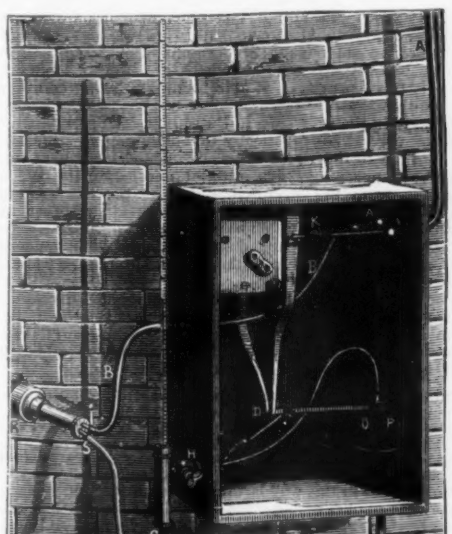


FIG. 3.—INTERRUPTER.

rent of water, whose discharge is known, to circulate in a capsule placed in a furnace whose temperature it is desired to ascertain. The water becomes heated, and, from the difference between the temperature at the entrance to and exit from the interior, we deduce the temperature of the latter, provided the discharge be regular and constant.

In 1882, Prof. Amagat, of the Faculte de Lyon, patented a similar pyrometer, in which the water circulated through a double worm in the interior whose temperature was to be ascertained.

The Messrs. Boulier Bros.' pyrometer is founded upon the same principle as the ones just mentioned. It consists of three distinct parts that are shown united in Fig. 1, viz., of an explorer, a reservoir, and an interrupter. The explorer, which is the interesting part of the apparatus, and which is shown in section in Fig. 2, consists of a small cylinder, E, of very thin copper, a few centimeters in length. One of its extremities is closed, and the other one communicates with two tubes, one of which, I, is in communication with the reservoir, and the other, S, with a thermometer and the interrupter. The water coming from the reservoir circulates in the small cylinder, A, becomes heated therein, and comes in contact with the thermometer that shows its temperature. The two tubes are inclosed in a long metallic cylinder which serves as a support to the explorer and allows it to reach all parts of the furnace. This cylinder, which is about one meter in length, is provided with a non-conducting sheath, and carries in its interior a second circulating system, the water of which enters at M and makes its exit at N. The object of this is to keep the temperature of the cylinder constant, so that the heating of the water shall only proceed from the action upon the extremity, E, of the explorer, that is to say, so that it shall depend only upon the temperature of the interior in which the explorer is placed.

The reservoir merits no special mention. It must be a constant level one, so that the flow shall be regular, and it is for this reason provided with a waste pipe.

To use the pyrometer, the explorer is first connected with the water reservoir by means of rubber tubing, and, after it has been ascertained that the circulation is proceeding regularly, it is introduced into the furnace or muffle, and firmly fastened to the door or any other part. A few moments after this, observations may be begun.

The water from the reservoir circulates in the apparatus, becomes heated in contact with the flames or hot air, and shows by the thermometer the variations in temperature that it is undergoing. These indications occur very rapidly, it taking but a few seconds for the thermometer to get into action. The apparatus is so sensitive, that a simple contact of hand with the cooler (the water in the reservoir being at about 15°) will in a few seconds cause the thermometer to rise. This latter is graduated to twentieths of a degree. When the flow is well regulated, the temperature of the waste water does not exceed 35° for the highest temperature reached in porcelain furnaces, and it is always a matter of surprise upon removing the explorer from an interior at a temperature of 1,200° or 1,500° C., to find that it is scarcely tepid.

The graduation of the scale of high temperatures may be effected in several ways, for example by immersing the calorimeter, E, in air confined in a mass of boiling water. If the water used for the experiment be at zero, the degree of variation of the thermometer column will represent 100° (temperature of boiling water), and it will be only necessary to graduate the surplus of the scale proportionally. It goes without saying that the discharge of water for any given temperature must be constant, and equal to that which has been used for effecting the graduation. This result is obtained by always having the same difference of level between the level of the water in the reservoir and that of the discharge.

The interrupter (Fig. 3) is a safety apparatus which was gotten up by the Messrs. Boulier on an order from Mr. Lauth, who, at first, had some fears as to the working of the explorer, and as to the results that might occur from the sudden introduction of water into a furnace at a white heat. The apparatus consists of a small balance that remains in equilibrium as long as the current of water is operating with regularity, but, at the least interruption in the circulation, throws an alarm into gear, and even shuts off the water. To this end, the water coming from the explorer at S (Fig. 3) and traversing the cylinder, C, in which the thermome-

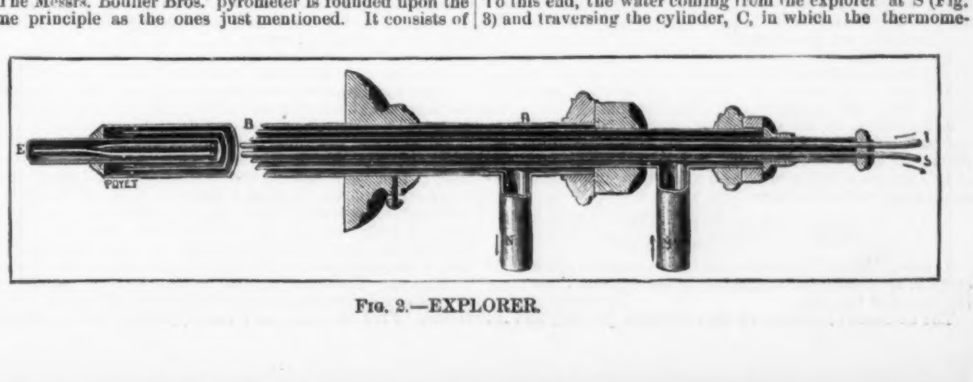


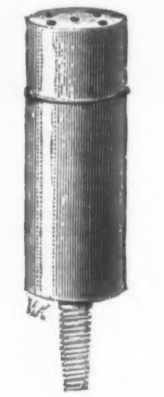
FIG. 2.—EXPLORER.

ter reservoir is inclosed, flows into a small glass funnel which is suspended from a lever that remains horizontal as long as the discharge is constant. If the flow diminishes, the level, O P, in the funnel will lower, the weight will decrease, and the lever will tilt, and in the first place free at D the alarm, and then, through the intermedium of a second and vertical lever, free the weight, K, which, falling vertically as shown by the dotted lines, will close the cock, A, through which the water is entering.

In his report to the Societe d'Encouragement, Mr. Lauth, the director of the Sevres works, states that this pyrometer shows the rise and fall of the temperature in the interior in which it is placed, very faithfully and very rapidly. The only fault that can be found with it is that it is not very portable, and requires a large quantity of water to operate it (25 to 30 cubic meters for a single baking). But this is a matter of secondary importance in an operation in which works of art of an inestimable price may be injured or ruined through the poor behavior of a furnace. The Messrs. Boulier should be thanked for having put into the hands of savants and manufacturers an apparatus capable of rendering so important services.—*La Nature.*

AIR-FILTER FOR WINE CASKS.

AN ingenious manufacturer, of Reims, a Mr. Berthelot, has recently made a new and very happy application of Mr. Pasteur's doctrines, apropos of packages of wine that are put on tap. When a package of wine is tapped and provided with a wooden faucet, it is necessary, as every one knows, to bore a hole in the upper part of the cask in order that the liquor may flow when the cock is turned on. Butlers take care to stop up this aperture with a wooden spigot, for if it is not closed every time the liquor is drawn, the wine sours. Why? Because atmospheric air gets into the wine through the aperture, and the germs that it contains develop therein. As a substitute for the spigot, Mr. Berthelot has devised the little apparatus shown in the accompanying cut. It consists of a simple, hollow, metallic cylinder,



which contains a wad of cotton, and which is screwed permanently into the cask. The air, in passing through the cotton, becomes filtered and freed from all its dust and germs, and no longer has any influence upon the wine.—*La Nature.*

THE MANUFACTURE OF SODA BY THE AMMONIA PROCESS.

By Dr. JULIUS KOEBIG.

WHEN Napoleon the First excluded about a hundred years ago all English trade from the European continent, the most important question arose how to furnish the absolutely necessary products hence imported by English vessels to the Continental market. Among these the soda ranged in the first line, because almost all manufacturing depended then, as well as now, more or less on this very product. The Spanish soda, although a good one, became too expensive, especially after the exclusion of the transmarine competition, and the experiments already begun several years ago by the most prominent chemists of France to produce the soda directly out of the common salt attracted the careful attention of the French government. I give here the *decret* of the Committee of Common Welfare issued in 1793, which evidently shows the importance of this product. In consideration of the duty of the republic, which commands to her to direct the force of freedom with all her power on all matters that are the basis of the most important branches of industry, duties which further command to her to reject the boundaries of dependency in trade and to produce to daylight all that nature has put in her bosom, as much in order to weaken the hated means of enforcement as to develop the deeds of the soil and of the industry; in consideration of all this resolved and all citizens held within two decades, to deposit with a special committee for the benefit of the community and without regard to all private profit and speculation, all processes known to themselves for manufacturing soda. Among the reports delivered to the committee on account of the above *decret* was that of Nicolas Leblanc; and although the appointed members of the committee did not offer the first prize to this process, it proved in the future the most economical and by far the most practical one. In France, England, and Germany manufactures on this process were built, and immense quantities of soda were produced, almost entirely throwing out of the market the product of the soda-lakes of Africa and America and of the combustion of sea water plants.

The well known principle of the Leblanc process is: 1. Transformation of salt into sulphate of sodium and hydrochloric acid by heating the chloride of sodium with sulphuric acid, $2NaCl+H_2SO_4=Na_2SO_4+HCl$.

2. Reduction of the sulphate of sodium by coal and in the same time transformation of the resulting sodium sulphide into carbonate of sodium by limestone, the products of this operation being carbonate of sodium, sulphide of calcium, and oxide of carbon:

$$Na_2SO_4+HCl=Na_2S+4CO.$$
$$Na_2S+CaCO_3=Na_2CO_3+CaS.$$

3. Separation of the soda from the insoluble sulphide of calcium by dissolution of the first in boiling water and crystallization of the soda.

The enormous influence of this Leblanc process, and the rapid progress in the execution of it, may be illustrated by the following prices of soda: One ton of crystallized soda cost in 1814, $300; 1824, $75; 1861, $22.50; 1865, $20.

Nevertheless, this is an undeniable big success; and although most of the soda now in market is produced by the Leblanc process, there are serious objections against it. In the first line there is an immense quantity of waste products, which contain the whole amount of sulphur used in the course of manufacturing. It is put in as valuable sulphuric acid, and at the end thrown aside as worthless sulphide of calcium. This waste product forms a very inconvenient wall around the factory and kills every vegetation left in its neighborhood by the hydrochloric acid and chlorine, besides that being hard on the health of the laborers by its evaporations in decomposing by the influence of the atmosphere. And even if all these inconveniences would not be considered, it enforces upon the manufacturer the necessity to cover large sections of land by worthless stuff and to pay big expenses to transfer it there from the factory.

Further, require the complicated series of operations, an extensive and complicated apparatus, and a large amount of labor and fuel to run it, and consequently a large capital for the erection and maintenance of the factory.

And last, not least, the inevitable immense quantity of hydrochloric acid produced as by-product is a serious annoyance. It is true that in the first time of the practical manufacturing the hydrochloric acid was a valuable thing, and met with at least a satisfactory demand either in the form of the acid itself or of bleaching powder. But by and by the law put stronger rules on the manufacturers, in order to prevent them from allowing noxious gases going into the open air, and in consequence the condensing apparatus became more perfect, but more expensive too; in the same time the demand and also the production of soda increased rapidly, and so an enormous overproduction of hydrochloric acid resulted, and depressed the price of the same so much that to-day the crude hydrochloric acid does not only not pay a profit, but is often sold below the actual cost only in order to get rid of it.

Among the various efforts to overcome these difficulties, either by changing the process entirely or by entirely abandoning it in following other principles of producing soda, so far only two have been successful. One is the industry that depends on the decomposing of cryolite; it is a success, but at the same time its possibility is limited by the extension of the cryolite deposits in Greenland, as until now this mineral has not yet been found in any other location on the earth.

The other one is the ammonia soda process, the principle of which is the most simple possible: In an almost saturated solution of sodium chloride in water, bicarbonate of ammonia precipitates the bicarbonate of sodium, sal ammoniac remaining in solution. The latter can be decomposed by lime, forming chloride of calcium and ammonia, which is used over again to precipitate another quantity of chloride of sodium by aid of carbonic acid. The bicarbonate of sodium is for itself a marketable product, or can be transformed by heat in soda ash and carbonic acid. The first patent in this line was taken out already in 1838 in England by Hemming, Ayar, Grey, and Harrison, and has since been the object of continuous study and experiments, in the course of which the process itself has not changed, on account of its fundamental simplicity. All who occupied themselves with it tried to overcome the only difficulty that is in it by constructing an apparatus tight enough to avoid the loss of ammonia and that would allow a continuous working. In both directions we can register a success, and now the Leblanc process has got a dangerous competitor that has already in many cases proved to be able to throw the latter out of competition.

Already in the year 1854, in Puteaux, near Paris, this process was carried out practically by Schloesing and Rolland, but not until the experiences of alcohol distillery furnished an apparatus which allowed to separate the gaseous ammonia from the steam, and thus to prevent the concentrated salt solution from being diluted, and other important improvements in manufacturing iron apparatus and airtight connections, it gained an importance which rendered it a dangerous competitor to the Leblanc process and to any other one.

The first who succeeded in using the ammonia process was Solvay; he built a factory in Couillet near Charleroi, Belgium, in 1865, where he used an apparatus patented in France, Belgium, and U. S. A. In 1873 he produced already 4,000 tons, and in 1878 he had manufactories in:

Couillet, Belgium,	with a production of	7,500 tons a year.
Vorangeville-Dombasle,	" " "	20,000 " " "
England,	" " "	13,000 " " "

This shows to evidence that only a perfect apparatus was necessary to make the process a practical one. The soda manufactured in this way is of greater purity, and contains 98 per cent. of pure carbonate of sodium at least, or what is the same, 58·5 per cent. of alkali, while the Leblanc soda only shows a percentage of 48 of alkali. In the course of the last years the production of the above mentioned factories has largely increased, and a number of new ones has been erected all over Europe.

Such a success encouraged several other chemists and chemical engineers to try their chances in improving the Solvay patent, or to try some new principles for the same purpose. Among these may be mentioned James Young, H. De Grousillier, and Siemens and others. The best and most perfect apparatus is owned by Gerstenhoefer and Honigmann. They constructed it so carefully and skillfully that there is almost no loss of ammonia, and a continuous working is possible by the ingenious arrangement of the so-called universal apparatus of theirs. It is not my intention to give a full account of the manufacturing practice, but I think it expedient for better understanding the principle, as well as the advantages of the process, by giving a short abstract of the arrangement and working of the best plant that has been until to-day brought forward.

The chief apparatus of Gerstenhoefer is his universal apparatus, an iron tank about twice as high as its diameter, through the top of which a three-way pipe allows to supply the tank alternately by salt brine, ammonia, and carbonic acid. The ammonia is produced in a still furnished with a rectificator and a dephlegmator to retain all water, so that the brine will not be diluted. The carbonic acid comes from a lime kiln and is first compressed, and then, after being cooled down, expanded again in order to produce a sufficiently low temperature. During the time the brine is charged with ammonia as well as with carbonic acid, to produce the bicarbonate of ammonia, and, by chemical reaction of the latter on the chloride of sodium, of the wanted bicarbonate of sodium and sal ammoniac, the contents of the universal apparatus are carefully kept cool by a refrigerator. Five of these universal apparatus form a battery allowing continuous work in the following manner: When all five are charged with brine, 1 receives ammonia, gas, and sufficient carbonic acid to form monocarbonate of ammonia. 2 and 3 act as absorbers for waste gases of the same character.

In the second period the 1 receives the balance of carbonic acid gas to produce bicarbonate of ammonia, which by reaction of the brine produces insoluble bicarbonate of sodium and chloride of ammonia. The 2 receives ammonia gas and sufficient amount of carbonic acid to form monocarbonate of ammonia as 1 in first period. 3 and 4 act as absorbers of waste gases.

In the third period 1 is emptied and cleaned; 2 receives the second equivalent of carbonic acid to form bicarbonate of ammonia and in succession bicarbonate of sodium; 3 receives ammonia and carbonic acid to form monocarbonate of ammonia; 4 and 5 act as absorber of waste gases.

In the fourth period 2 is emptied and cleaned, 3 charged with second equivalent of carbonic acid, and 4 with ammonia and the first half of carbonic acid gases; 5 and the previously charged with fresh brine 1 act as absorber, and so on.

In this way always four of the compartments are used, and the fifth is emptied, cleaned, and charged with brine.

To describe the ingenious apparatus and machinery for transporting the bicarbonate of sodium and the solution of chloride of ammonia containing an excess of ammonia, and carbonates, ammonia and the non-transformed salt (about 40 p. c. and less of the original contents of the brine) to the stirring apparatus, filter press, and centrifugal machine in a perfectly airtight system of pipes, etc.; further the reconducting of the ammonia as well as the carbonic acid from the still and calcining apparatus in the process; finally, the skillful arrangement of the self-acting valves of these two latter compartments, would lead me too far for the purpose of this essay. It may be sufficient to state that by these apparatus, patented in the U. S. A. by Moritz F. J. Gerstenhoefer, the only serious objection against the practical use of the ammonia soda process is altogether avoided. And, in fact, there are factories in the old country working on the Gerstenhoefer plant, whose loss of ammonia is really a trifle. Everybody who knows the difficulty to construct ammonia ice machines that exclude the loss of the acting agent will appreciate the ingenuity to render so large a plant "ammonia-tight."

The only waste product of this process is chloride of calcium and of magnesium, according to the percentage of magnesium carbonate in the originally used limestone. This is by far not so valuable in its contents as the sulphide of calcium in the Leblanc process, and will not create any annoyance around the works. But even if it should be wanted to save the chlorine in the form of hydrochloric acid or bleaching powder, this would be practically possible according to the Solvay patents on this subject, while all efforts to save the immense amount of much more valuable sulphur accumulated around the Leblanc soda works have failed.

As I consider it only a question of time that this process will be introduced in this country on a large scale, the demand of soda being increasing and large enough to protect an industry on a large scale, I will give some figures showing the advantages of it before the Leblanc process, and at the same time the possibility to compete successfully the European industry. The figures given are carefully worked out by the inventor and checked by myself.

The following statements are obtained from the statistics of the alkali trade of the United Kingdom of Great Britain, given by the Alkali Association of England, in 1876, for the Leblanc process and for the ammonia soda process from personal investigation of actual working results in Germany.

The Ammonia Soda process requires per ton of carbonate of soda (soda ash):		Leblanc Process requires per ton of carbonate of soda (soda ash):
Common salt	1·16 tons.	1·068 tons.
Limestone (and lime)	1·02 "	0·861 "
Coke and coal	0·98 "	2·236 "
Pyrites	— "	0·445 "
Saltpeter	— "	0·014 "
Manganese	— "	·021 "
Total materials	3·16 "	4·645 "

The capital employed for producing one ton of soda ash is:

Ammonia Process:	Leblanc Process:
$37·037 (7·5 tons daily prod.)	$40·177
31·26 (40 tons daily prod.)	

The actual cost of one ton of soda ash produced by the ammonia soda process as well as by the Leblanc process depends very much on the local facilities, and cannot be given in general terms. According to my estimates for a not very favorable locality in the southern part of this country, where salt brine, coal and limestone are pretty far away, but wages, etc. are low, the cost of one ton of soda is $32.83 ready for shipment.

It contains 58 per cent of alkali and can be sold at the rate of $36·50 (1.62 cents a pound. In the above cost of $32·83 a ten per cent. interest of the invested capital is already included, so that the net profit will be:

$3.67 per ton, or		
9.9 per cent.	Production 7½ tons daily.	
or 11.7 " "	" 40 " "	

These estimates are undoubtedly in favor of the manufacturing after the ammonia process, and will in practice still more prove so, the price of almost chemically pure soda ash of 1.62 cents a pound being much too low, and there will be no difficulty to raise it to 1.70 to 1.80 cents.

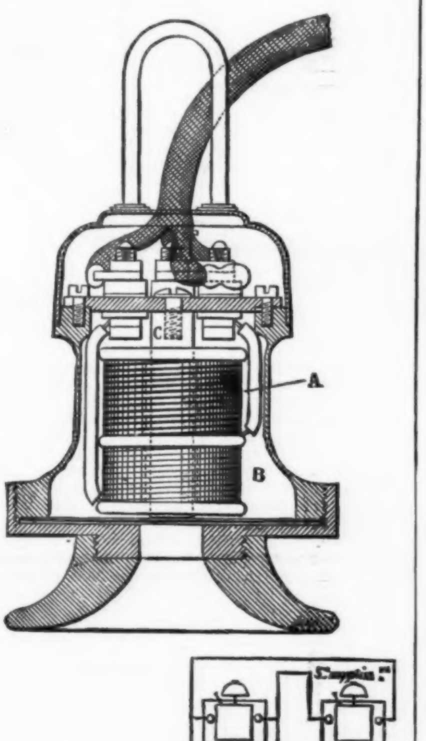
Where the national resources of a country are so rich and the immense capital in so skillful and clever hands as in the United States, they will soon give origin to an industry of chemical products that can frankly compete with the old country, as they already have in so many other branches of manufacturing. The soda industry will be one of the first in this line, because it is the *conditio sine qua non* of most of the other ones, and the ammonia soda process will also prove its importance here as well as it has done already beyond the Atlantic Ocean.

IF a contrivance, a design of which has been submitted to the Australian Minister for Water Supply, be successful, one of the greatest enemies of the farmer—drought—will, to some extent, be avoided. It is a machine for bringing down rain, and is in the form of a balloon, with a charge of dynamite underneath it. The balloon is to be sent into the clouds, and the dynamite is to be fired by a wire connecting it with the earth.

DUCOUSSO'S TELEPHONE.

In the telephone apparatus usually employed the induced currents that transmit and reproduce speech traverse the induction and receiving bobbins in the two stations; and yet it would suffice were the fine wire of the induction bobbin in the line circuit during transmission, and were only the receivers in the circuit at the moment of receiving. Use is no longer made of those hand-actuated interrupters that permitted the generator or the receivers to be placed in the circuit according as transmitting or receiving was being done. It is probable that, by reason of the high tension of telephonic currents, the bobbin resistance in the circuit does not perceptibly lessen their intensity; but these bobbins are provided with magnetic cores that necessarily react upon them, and this effect may interfere with the distinctness with which the hearing may be done.

Mr. Ducousso's telephone is arranged in such a way as to utilize the fine wire bobbin for transmitting as well as for receiving. It consists of a soft iron core, C, one of the poles of which faces an ordinary soft iron diaphragm. This core is surrounded by a fine wire bobbin, B, that corresponds to the line circuit. Alongside, upon the same core, there is a coarse wire bobbin, A, that corresponds to the pile and microphone circuit. The variations in the intensity of the primary current in the last named circuit give rise to



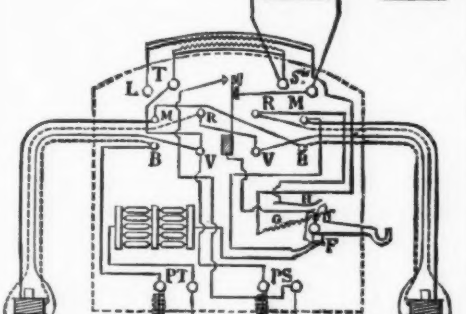


FIG. 1 ET 2

DUCOUSSO'S TELEPHONE.

induced currents in the bobbin, B, by reason of its proximity, and also through the intermedium of the soft iron core, C, which is the seat of a variable magnetic state depending upon the primary current. At the receiving station, the microphone being mute, the core, C, is constantly magnetized, but the induced or other currents that pass into the bobbin, B, modify such magnetism according to their form, and the diaphragm is similarly actuated.

In ordinary stations, where two receivers are usually employed, the inducting bobbins of the two telephones are arranged for tension, and the same is the case with the induced ones. And yet, in particular cases, it may be preferable to arrange the inducting bobbins for quantity and the induced ones for tension, or, we may have two piles and one microphone acting upon the same receivers.

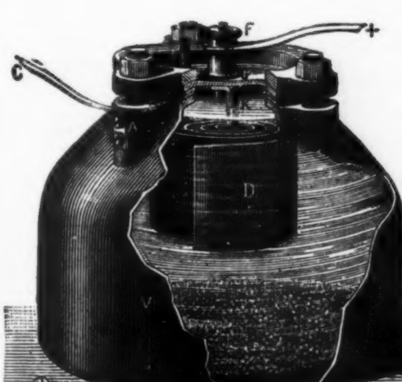
The absence of a permanent steel magnet renders the construction of this apparatus simpler and more convenient to use. It is very light, and its shape is very graceful.

The inventor claims the following advantages for his apparatus: (1) Suppression of the permanent steel magnet; (2) an arrangement that permits of a complete utilization of the internal resistances, in transmitting as well as in receiving; and (3) the facility of grouping the inducting and induced bobbins for tension or for quantity.—*La Lumière Electrique.*

LALANDE AND CHAPERON'S OXIDE OF COPPER BATTERY.

After a long series of researches with the object in view of constructing a voltaic pile of long duration and capable of furnishing a large and continuous discharge, Messrs. Lalande & Chaperon ascertained a general way that the end might be attained by an association of the properties of oxide of copper and alkaline solutions. Their first oxide of copper pile, based upon this principle, was made known by them in the year 1881. Since that period various other models have been brought out. Besides those that have already been described in scientific journals, the house of Brauville is constructing some with an external vessel of cast iron that present the advantage of being hermetically closed, of being easily transportable, and of possessing great compactness and strength, the latter being a very important character for elements containing a caustic liquid.

In one of these models (Fig. 1) the external vessel, which is 0·09 m. in diameter, has the aspect of a projectile. It constitutes the positive pole of the pile. The projection, A, serves for affixing the conducting strip, AC, that is designed for making connections. The outside of the vessel is paraffined while hot so as to render it inoxidizable and prevent induction. The zinc, D, is a cylinder, 0·02 m. in diameter, soldered to an amalgamated brass rod K, which is fixed to



FIGS. 1 AND 2.—LALANDE AND CHAPERON'S OXIDE OF COPPER PILES.

the rubber stopper, G, and carries the terminal, F. The stopper is also traversed by a metallic tube that terminates in a valve, H, formed of a split rubber tube.

These piles are usually delivered filled with solution of potassa, so that, in order to mount them, it is only necessary to pour in the proper quantity of oxide of copper (which distributes itself over the bottom) and close the vessel by means of the rubber stopper.

This arrangement is particularly adapted for use in apartments, for telephones, bells, etc. It is capable of giving a current of 2 amperes. A smaller model, 0·05 m. in diameter, amply suffices for a service of several years in connection with an apartment call bell.

Fig. 2 represents another type of hermetical pile which has more recently been put in service. It has a large surface, and is capable of giving an 8 or 10 ampere current, thus permitting of its being employed for the same purposes as Bunsen, bichromate, and other piles—charging accumulators, domestic lighting, electrometallurgy, etc. The arrangement of this pile is very similar to that of the preceding. The oxide of copper, B, is here likewise spread over the bottom of the vessel. The zinc, D, which consists of a long strip rolled spirally so as to present a wider surface, is suspended from an ebonite cover, G, fixed to the mouth of the vessel by a ring and three nuts and screws. The joint is made tight by the interposition of an India rubber washer.

These large-sized piles contain the same charge as the large trough piles (2 kilos of potassa and 0·9 kilo. of oxide of copper), and may be substituted for them in all applications. They are capable of furnishing a large amount of work. For example, a battery of trough piles has furnished light for two hundred hours with a 5-candle Edison lamp.

These cast iron piles present the remarkable property of giving, without polarization, a greater discharge than do those corresponding piles whose conducting surface *in contact with the oxide of copper* is just as large. Although no hydrogen is disengaged from the iron, Messrs. Lalande & Chaperon think that the wide surface of the latter must nevertheless become charged with occluded hydrogen, which goes progressively to the oxide of copper and thus continuously concurs in the work of depolarization.—*Chronique Industrielle.*

[For THE SCIENTIFIC AMERICAN.]

SERIES OF ORGANIC SUBSTANCES.

Arranged by OTTO SCHNURRER, Brooklyn, N. Y.

It would not seem to be a work of supererogation to arrange the principal organic substances into one comprehensive system, or series, of allied bodies, in tabular form, by the strict application of a leading principle of classification, which, in the following trial, has been taken to be the quantitative relation by weight that exists between carbon and hydrogen in their various compounds. The kind criticisms of competent readers of the SCIENTIFIC AMERICAN are invited to point out possible defects, to state objections, and to suggest improvements, in order that this trial series may become what it is intended for, to wit, a reliable guide and ready table of reference for the student of chemistry and pharmacy.

I. LIGHT CARBURETED HYDROGEN SERIES.

CH_2 Marsh gas, fire damp. Ratio of C : H :: 3 : 1.
C_2H_3 Methyl. " " :: 4 : 1.
C_4H_5 Ethyl 2(C_4H_5) rigolene from petroleum.
C_5H_6 2(C_5H_6) gasoline " Ratio 5 : 1.
2(C_5H_6)+NH_2 ammoniated gasoline or curaria from woorari $C_{10}H_{15}N$.
C_6H_7 Propyl 2(C_6H_7) naphtha from petroleum and light oil of tar, or benzine.
C_7H_8 2(C_7H_8) kerosene from petroleum; and
C_8H_9 2(C_8H_9) " from heavy oil of tar.
C_9H_{10} 2(C_9H_{10}) paraffine from petrol. and oil of tar.
$C_{10}H_{11}$ Amyl 2($C_{10}H_{11}$) amyl from petroleum and light oil of tar.
($C_{10}H_{11}$)O.NO_3 nitrite of amyl.
$C_{16}H_{17}$ 2($C_{16}H_{17}$) petrolatum, vaseline, cosmoline.
$C_{24}H_{25}$ 2($C_{24}H_{25}$) pitch. Ratio less than 6 : 1.

II. HEAVY CARBURETED HYDROGEN SERIES.

CH Olefiant gas. Ratio of C : H :: 6 : 1.
C_2H_2 Methylen 2(CH)+HO hydrated methylen or methyl ether C_2H_3O.
2(CH)+2(HO) bihydrat. methylen or methyl alcohol, or wood spirit, pyroxilic spirit ($C_2H_4O_2$).
2(CH)+Cl_2 bichloride of methylen or chloro methyl.
C_4H_4 Ethylen 4(CH)+HO hydrated ethylen or ether (sulphuric) C_4H_5O.
4(CH)+2(HO) bihydrat. ethylen, or alcohol, $C_4H_6O_2$.
4(CH)+Cl_2 bichloride of ethylen, Dutch liquid.
C_6H_6 Eupion from heavy oil of tar.
C_6H_6 Propylen 6(CH)+NH_3 propylamine or ammoniated propylen C_6H_9N.
$C_{10}H_{10}$ Amylen 10(CH)+HO hydrated amylen, amylic ether.
10(CH)+2(HO) bihydr. amylen, amylic alcohol, fusel oil.
10(CH)+O_4 valerianic or amylic acid.
10(CH)+O_4+2HO bihydr. valerianic acid.
$C_{13}H_{13}$ 13(CH) caoutchouc.
20(CH)+O_2 oil of rue (ruta) $C_{20}H_{20}O_2$.
34(CH)+O_4 margarin, margaric acid.
36(CH)+O_4 stearine, stearic acid.
2($C_{18}H_{17}$)+O_4 oleine, oleic acid.
4($C_{14}H_{13}$)+O_8 castor oil.
($C_{21}H_{20}$)O_2 oil of peppermint.
2($C_{10}H_9$)O_2 oil cajeput and oil of coriander.
($C_{10}H_9$)O_3+HO valerianic acid; see also above.
4(C_6H_5)O_2 oil of valerian $C_{24}H_{20}O_2$.

C_5H_4. Camphene series. Ratio of C : H :: 7½ : 1.
2(C_5H_4) gutta percha.
3(C_5H_4) rectif. oil of amber.
4(C_5H_4) camphene, fresh spir. turpentine.
4(C_5H_4)O old spir. turpentine, also oil of juniper and oil of camphor.
4(C_5H_4)O_2 gum camphor.
10(C_5H_4)O oil origan.

C_4H_3. Acetyl. Ratio 8 : 1.
(C_4H_3)Cl_3 terchloride of acetyl (Dutch liquid).
2(C_4H_3)+O_2+2(HO) acetic ether $C_8H_8O_4$.
5(C_4H_3)O oil of caraway.
5(C_4H_3)O_2 resin.
6(C_4H_3)O_7N_3 protein, albumen.

$C_{10}H_7$. Ratio 8⅐ : 1.
2($C_{10}H_7$)O_2 thymic acid, thymol from oil of thyme $C_{20}H_{14}O_2$
2($C_{10}H_7$)O_6+2HO camphoric acid........20 16 8
3($C_{10}H_7$)O oil of horsemint.................30 21 1
4($C_{10}H_7$)O_{10} elaterine from elaterium.....40 28 10
$C_{13}H_9$. 2($C_{13}H_9$)O_{14} salicine..........................26 18 14

C_3H_2. Ratio 9 : 1.
(C_3H_2)+HO acetone, pyroacetic ether.....$C_3H_3O_1$
($C_{13}H_8$)O_2 fennel oil..........................13 8 2

C_5H_3. Ratio 10 : 1.
4(C_5H_3)O_2 anis oil..................................$C_{20}H_{12}O_2$
4(C_5H_3)O_4 oil of cloves..........................20 12 4
6(C_5H_3)O_6 santonine...............................30 18 6
4(C_5H_3)+NO cinchonine...........................20 12 NO
8(C_5H_3)+2(NO) cinchonidine.......................40 24 2 2
8(C_5H_3)+2(NO_2) quinine and quinidia......40 24 2 4

FORMYL SERIES.

C_2H. Ratio of C : H :: 12 : 1.

			Empirical formulas. C	H	O
6(C_2H)		benzole from coal naphtha or benzine..	12	6	—
10	"	O_4 sassafras oil	20	10	4
7	"	+HO amber	14	8	1
2	"	+2(HO) aldehyd (double formyl hydrate)	4	4	2
{2	"	O_2+2(HO) glacial acetic acid	4	4	4
{3	"	O_3+3(HO) lactic acid	6	6	6
{6	"	O_6 pyrogallic acid (see also below)	12	6	6
2	"	O_3+HO succinic acid	4	3	4
{2	"	O_4 malic acid	4	2	4
{6	"	O_{12}+HO citric acid	12	7	13
{6	"	O_{12}+3(HO) " cryst	12	9	15
4	"	O_{10}+2(HO) tartaric acid, cryst	8	6	12
2	"	O_6 formic acid	4	2	6
1	"	O_4 sublimed oxalic acid	2	1	4
1	"	O_4+2(HO) cryst "	2	3	6
1	"	N hydrocyanic acid (nitrogenated formyl) NC_2H.			
2	"	Cl_4 bichloride of formyl (Dutch liquid).			
1	"	Cl_3 terchloride of formyl, chloroform.			
1	"	I_3 iodoform.			

(C_2H)B_3O+HO bromal hydrate.

C_9H_4. Ratio 13½ : 1.
$2(C_9H_4)O_2$ oil of cinnamon $C_{18}H_8O_2$.

C_7H_3. Ratio 14 : 1.
$2(C_7H_3)+2HO$ creosote; uncertain $C_{14}H_8O_2$.

$C_{12}H_5$ Phenyl.
$(C_{12}H_5)NO_4$ artificial oil of almonds, or nitro benzole.

C_5H_2. Ratio 15 : 1.
$4(C_5H_2)$ naphthaline.

$C_{14}H_5$. Ratio near 17 : 1.
$(C_{14}H_5)O_2$ benzyl.
$(C_{14}H_5)O_3+HO$ benzoic acid (see also below).
$(C_{14}H_5)O_4$ salicyl.
$(C_{14}H_5)O_5+HO$ salicylic acid (see also below).

C_3H. Phenylen. Ratio 18 : 1.
$2(C_3H)+6HO$ glycerine........................ $C_6H_8O_6$
$4(C_3H)+2HO$ carbolic acid........................ 12 6 2
or phenylic alcohol, phenol.
$4(C_3H)+NH_3$ liquid anilin........................ 12 7 N
or ammoniated phenylen.

C_7H_2. Ratio 21 : 1.
$2(C_7H_2)O_2+2HO$ benzoic acid (which see also above).
$2(C_7H_2)O_4+2HO$ salicylic acid " "

C_4H. Ratio 24 : 1.
$(C_4H)O_2+2HO$ succinic acid (which see also above).
$3(C_4H)O_2+3HO$ pyrogallic acid " "
$(C_4H)Cl_3O_2+2HO$ chloral hydrate.

C_7H. Ratio 42 : 1.
$(C_7H)O_3+2HO$ gallic acid (dried at 212°)..... $C_7H_3O_5$
$2(C_7H)O_6+4HO$ gallic acid cryst.............. 14 6 10
$4(C_7H)O_{12}+6HO$ tannic acid, tannin............ 28 10 18

Hydrated carbon series. Ratio of carbon : water.
$C_{12}10HO$ wood, cotton, cellulose, starch, dextrine.. 8 : 10
$C_{12}11HO$ cane sugar, pure gum arab., arabine.... 8 : 11
$C_{12}12HO$ sugar of milk (see also lactic acid)... 8 : 12
$C_{12}14HO$ grape sugar, glucose.................. 8 : 14

[SCHOOL OF MINES QUARTERLY.]

GOLD CHLORINATION IN CALIFORNIA.

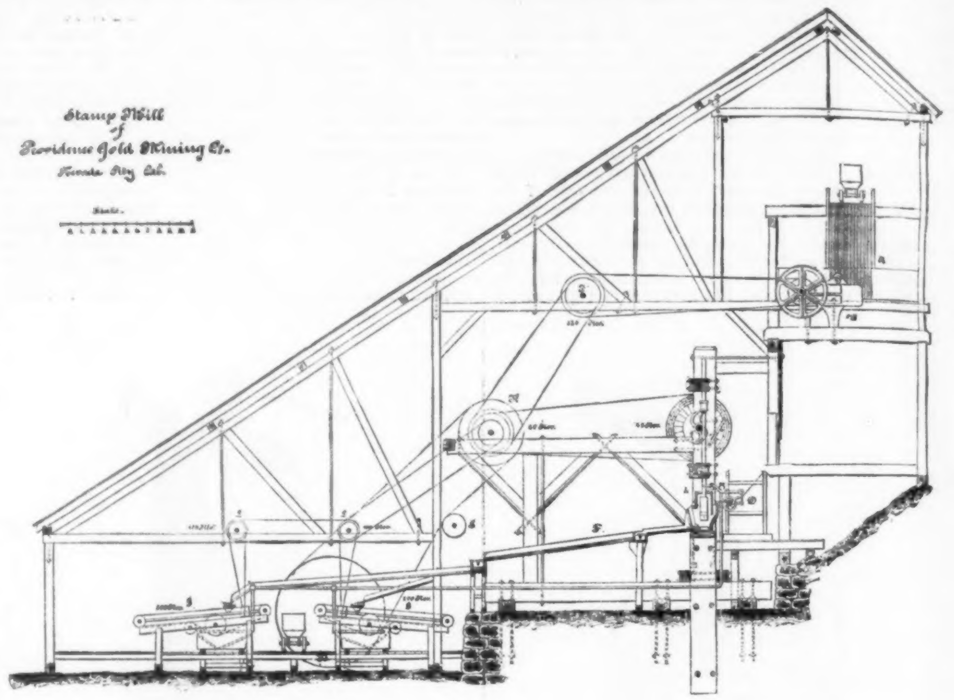
By F. D. BROWNING, E M.

GRASS VALLEY, California, has become famous as a gold quartz mining district. The country in composed of alternate belts of slate and granite. It is intersected in every direction by quartz veins, some of which cut across both the belts of slate and of granite, while others follow for some distance the dividing plane between the two formations and then strike off through either of them. A part of the gold found in these veins is free, and a part is contained in sulphurets. This is true of all the mines in the district, but the percentage of free gold and the character of the sulphurets vary greatly in different veins. The Idaho Mine, situated in the city of Grass Valley, is a good example of those carrying a large percentage of the gold in a free state; while the Providence Mine in Nevada City, four miles distant, exhibits the other extreme of heavily sulphureted ores. All the ores are worked by the same process, which is briefly as follows: The ore is stamped wet; the free gold is amalgamated in the stamp battery and on plates set below it; the tailings flowing off the plates are concentrated; and the concentrates are treated by chlorination. The system of stamping is quite uniform throughout the district. The methods employed for concentrating the tailings, however, are various, including the use of different forms of buddles, settling tanks, blanket sluices, etc., but unquestionably the best system is that in which Frue vanners are employed.

The Providence mill and chlorination works illustrate the best practice in the district and, so far as I know, in the country. It is proposed, therefore, in the following article, to give a full description of them.*

THE ORE AND ITS TREATMENT.

The Character of Ore.—The Providence gold ore is a heavily sulphureted quartz, which is hard and generally solid, though sometimes intersected by seams of chlorite. About seven per cent. of the total weight of ore are sulphurets, consisting mainly of pyrites with smaller quantities of galena, chalcopyrite, arsenopyrite, and a very little zinc blende. The proportion of free gold to the total amount in the ore was not ascertained.

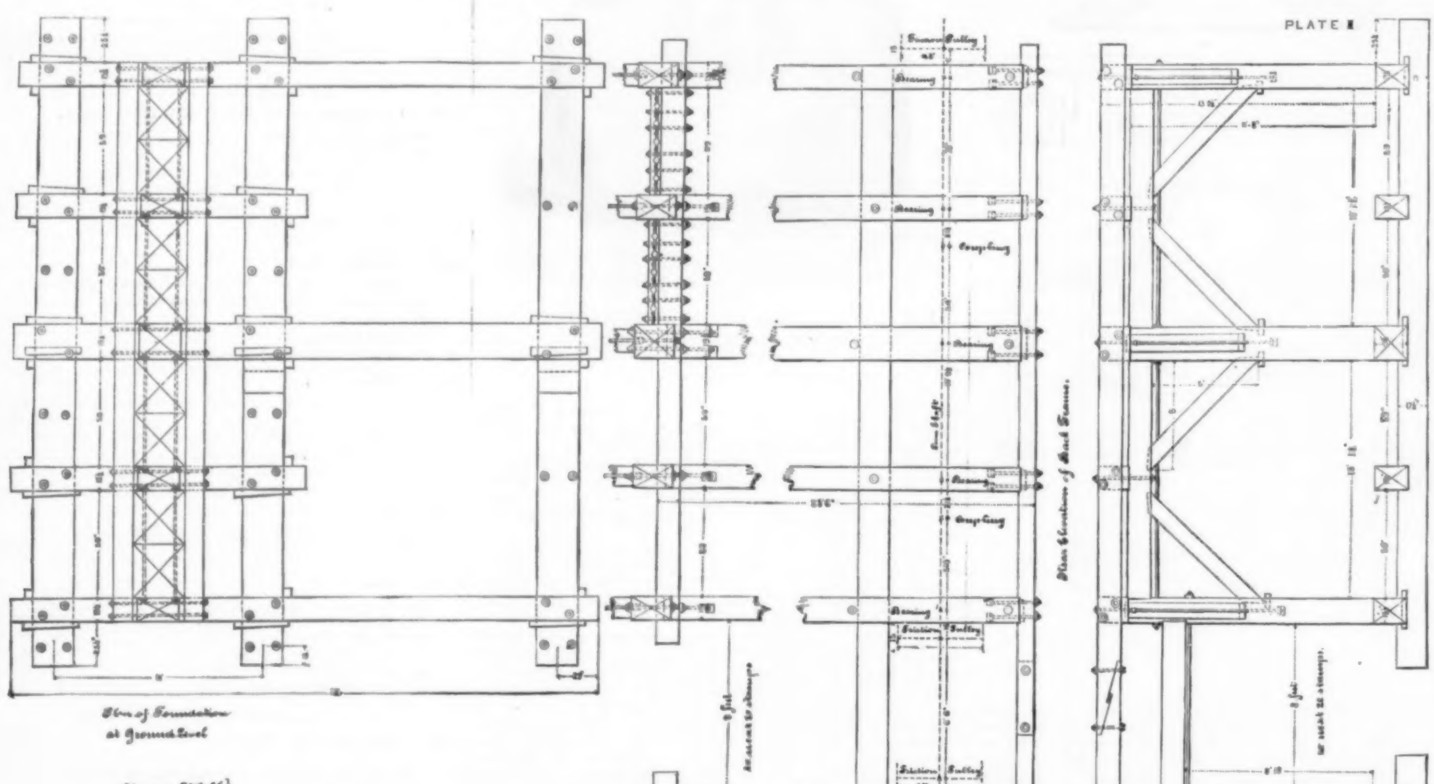


Milling.—Waste rock is separated from the ore in the mine, and is either filled into old stopes or sent to the surface during the night. All the ore is hoisted without sorting, and is sent over a tramway directly into a rock-house in the top of the mill. There it is dumped upon grizzlies through which the fine dirt falls into an ore bin, while the coarse rock passes over them and is delivered to rock breakers. In the coarse ore there are some pieces of nearly pure sulphurets, which are thrown to one side and treated separately; the balance of the coarse stuff is fed into the rock breakers, and falls from these directly into the same bin that holds the fine dirt. From this bin all the ore passes down chutes to automatic feeders, which deliver it to the stamp batteries. The ore is reduced in the batteries till it passes through a No. 5 punched screen; then it runs as a slime over silver-plated copper plates to Frue concentrators.

The stamps are run with a 7 inch drop, and at a speed of 96 drops per minute. The screens are equivalent in fineness to a 30 to 40 mesh sieve, according to the length of time that they may have been in use. The stamping, therefore, is coarse, and especially so because of a low discharge and a high speed; but the free gold is effectually released and is caught in the battery and on the plates, while that contained in the sulphurets is recovered from the concentrates.

The amalgamating plates are inclined 1¾ inches in 1 foot. This rather steep pitch is employed in order to keep the plates clean and yet avoid the use of much water, which would flood the concentrators. Water is used in the batteries in quantities only barely sufficient to keep the plates clean at this inclination; if there is an occasional banking up of sulphurets on the plates, the latter are readily cleansed with a hose. On the washing field of each Frue vanner just enough clear water is used to prevent the gangue from being carried with the concentrate over the head of the machine. Great care is taken to have the concentrators perfectly level, and their lateral motion properly adjusted, to prevent the sand from banking on either side of the traveling belt.

The tailings from the concentrators, being practically barren,* are run into the river; the concentrates, which prove remarkably clean,† are spread on the floor of an adjoining room to dry.



*I take this occasion to express my thanks to the Messrs. Walrath and to Mr. Hunter, owners and managers of this property, for the privilege of studying their operations and for the data furnished by them.

* Stated to contain but one-twentieth of one per cent. of sulphurets.
† Containing as a maximum 10 per cent. of sand.

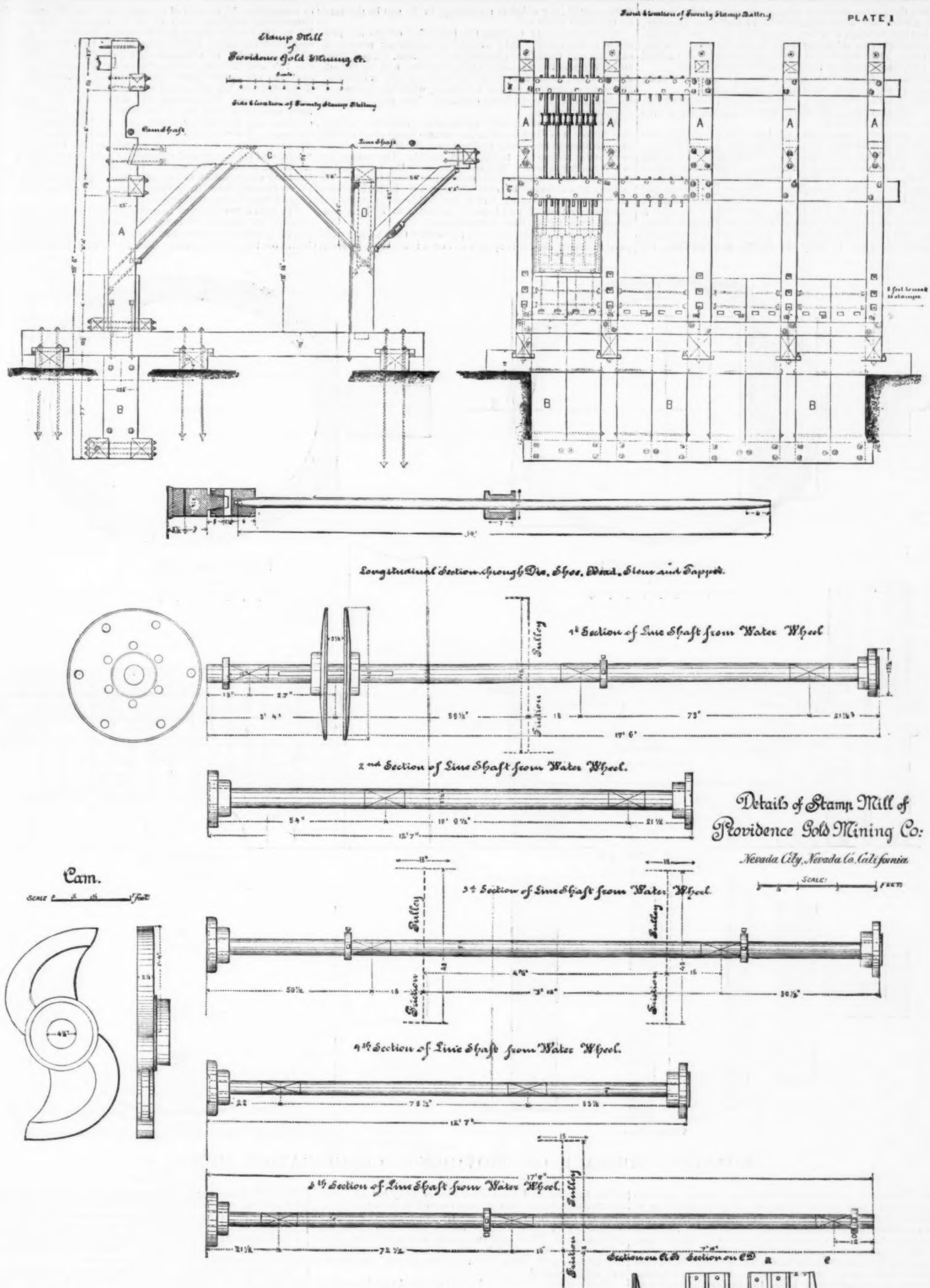


PLATE I
Stamp Mill of Providence Gold Mining Co.
Side Elevation of Twenty Stamp Battery
Front Elevation of Twenty Stamp Battery
Cam Shaft
Line Shaft
Longitudinal Section through Die, Shoe, Head, Stem and Tappet.
1st Section of Line Shaft from Water Wheel
2nd Section of Line Shaft from Water Wheel.
3rd Section of Line Shaft from Water Wheel.
4th Section of Line Shaft from Water Wheel.
5th Section of Line Shaft from Water Wheel.
Pulley
Friction
Cam.
Cam Shaft [4 the same as this]
Cam Shaft Boxes
Section on A B
Section on C D
Details of Stamp Mill of Providence Gold Mining Co:
Nevada City, Nevada Co. California.
SCALE

When the coarse pieces of sulphurets, picked from the ore in the rock-house, have accumulated in sufficient quantity, they are put through a battery separately, and from the battery plates the rich sulphuret pulp is run directly into settling tanks, from which it is afterward shoveled, and mixed with the concentrates on the floor of the drying room.

The dried sulphurets* are taken to the Chlorination Works, where they are roasted, chlorinated, and leached.

Roasting.—The roasting is performed in a three story furnace of elliptical plan, the third floor being the top of the furnace and not covered.

The sulphurets (henceforth called *ore* for convenience) are dumped on a brick floor level with the top of the furnace. After all the lumps are broken by working the ore over with a shovel, a charge is spread over the top of the furnace, four or five tons of ore being kept continually drying and heating, but no stirring is required. Thence the thoroughly dried and heated ore passes to the middle or second hearth, in which likewise five tons are kept. Here the ore is thoroughly stirred over at intervals of ten or fifteen minutes, and a great part of the sulphur is burned off, the temperature being sufficient to keep the charge at a medium red heat. The ore is next drawn to the lowest hearth—two tons being moved every twelve hours, or, if it be necessary to force the work, one and a half tons every eight hours. As often as this charge is drawn to the lower hearth an equal quantity is drawn down on to the second hearth, and the same amount is added on top of the furnace, the ore being so manipulated that the portion which has been longest on each hearth is drawn to the one next below. After the charge has been in the last hearth four hours the fire is allowed to go down a little, and one per cent. of salt is spread evenly over the ore. The fire is then raised to the regular temperature, keeping the ore at a bright red heat, and this is maintained until the roasting is complete—or for four hours when treating a charge of a ton and a half, and six hours for one of two tons. On the lowest hearth the ore is well stirred every ten or fifteen minutes till within half an hour of the time for drawing, when it is raked into a pile and so left until discharged.

One man tends the whole furnace, dividing most of his time between the middle and the lowest hearths, where all the stirring is done. It is very essential that the ore be perfectly roasted; any sulphur remaining in it can be detected by the smell when hot.

By this process of roasting the following effects are produced in the charge: Any arsenic or antimony present is oxidized and volatilized; the sulphides of iron, copper, zinc, and silver pass through stages of oxidation; and by the addition of salt most of the silver is converted into a chloride, and some chloride of copper is formed, while the balance of the base metals is completely oxidized. The gold is left in a free metallic state.

By conducting the process just as above described, except that the ore was discharged in one or two hours after adding the salt instead of in four to six hours, it was found that more silver was saved, but less of the gold. The reason for this is not far to seek. The more complete the roasting the more gold can be chlorinated, while some silver is carried off in form of a chloride by chloride of copper formed during the last stage of roasting, and is lost. The metallic gold is not thus carried off, and hence it is not lost by long continued roasting at a high temperature.*

The roasted ore is left in a pile under the furnace until partly cooled; then it is spread out on a brick floor in front of the furnace, and when quite cool is sprinkled with water and thoroughly intermixed. Just enough water is used to prevent any dust from rising when the ore is shoveled over; its consistency is such that it barely adheres when squeezed in the hand. The finer the ore the less water is required.

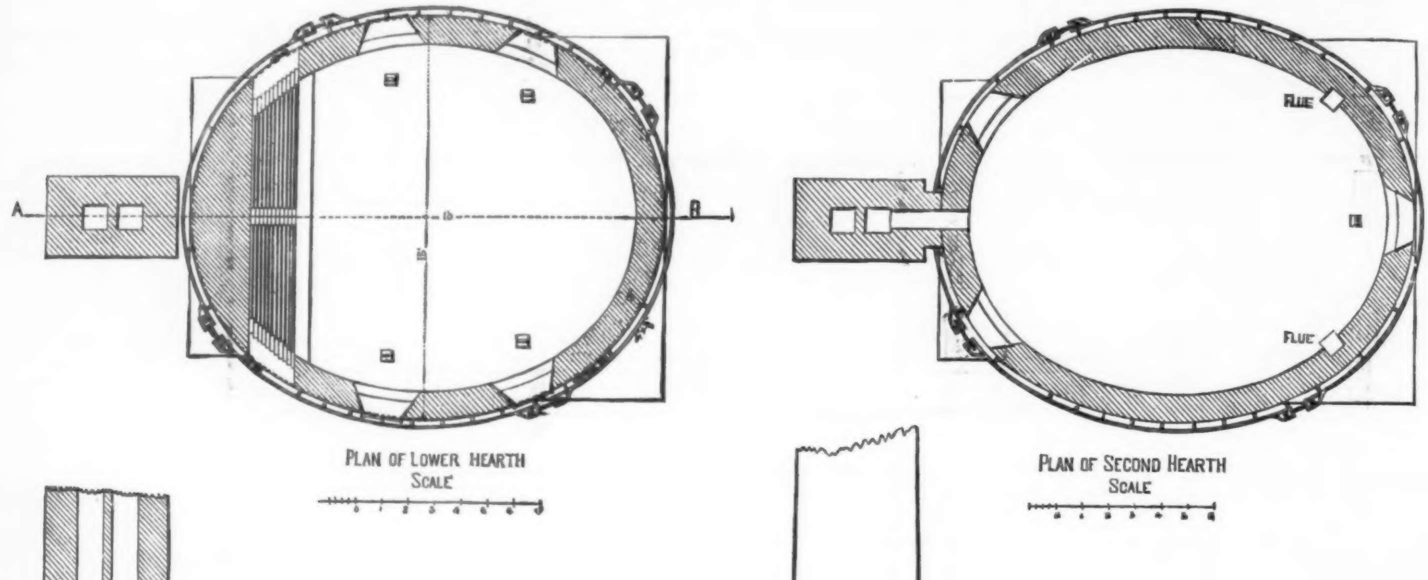
The ore is next passed through a six mesh sieve; all lumps hereby separated from the mass are ground in a small V mill and reroasted.

Chlorinating.—The sieved ore is shoveled into boxes holding about 50 pounds each, and these are emptied into chlorination tubs. If shoveled directly into the tubs the ore would pack, and subsequently prevent chlorine gas from permeating it freely. The tubs are filled to within two inches of the cover, and it is then put on; a groove left around its edge is calked with rags, and the joints are wetted and luted with plenty of tough dough, which is kept moist by a covering of wet cloths. Chlorine gas is then passed for 12 hours into the tubs, being admitted into each through a false bottom. Every tub holds 2¼ tons of ore, and as much chlorine is used for it as can be produced from 8 pounds of black oxide of manganese, 22 pounds of common salt, and 16 quarts of commercial sulphuric acid of 66° B. density. The ore is left in the tubs to digest and chlorinate for two, or preferably for three days. Chlorination should then be complete, which is tested by withdrawing a cork from the cover of the tub and holding an open bottle of ammonium hydrate over the hole; white fumes of ammonium chloride are seen if the chlorine has permeated the ore to the surface.

Leaching and Precipitating the Gold.—The gold having been converted into the terchloride by the action of the chlorine gas, is soluble in water and can be leached out of the mass. For this purpose a rubber hose is attached to a discharge faucet, the cover is raised, the ore flooded with water, and the solution of chloride of gold drawn into precipitating tanks. The ore is kept well covered with the leaching water, which continues to be supplied until the solution running into the precipitating tanks shows no trace of gold when tested with sulphate of iron.

The gold is precipitated in a fine metallic state by a dilute solution of sulphate of iron. An excess of the precipitant is added, and the solution well stirred and allowed to stand 24 hours for the gold to settle. The clear fluid is then drawn off, and is either run to waste or collected in a tank, where, if worth the operation, the copper it contains is precipitated on scrap iron. When sufficient gold has collected in the precipitating tanks to warrant a clean-up, it is dipped out into a cloth strainer; the water is drained off and the metal dried in a pan over a low fire; then it is melted in a graphite crucible in a small furface, and run into bars.

Extraction of the Silver.—The silver, mainly converted in a chloride in the roasting furnace, and for the greater part preserved intact during the process of chlorinating and leaching the gold, now remains to be extracted from the ore pulp. The extraction is based on the reaction of calcium hyposulphite and silver chloride, which results in the formation of a soluble double hyposulphite of calcium and silver; the precious metal can be precipitated from this solution as a sulphide by soluble polysulphide of iron, and the simple calcium hyposulphide left in solution is used over and over again for leaching.*



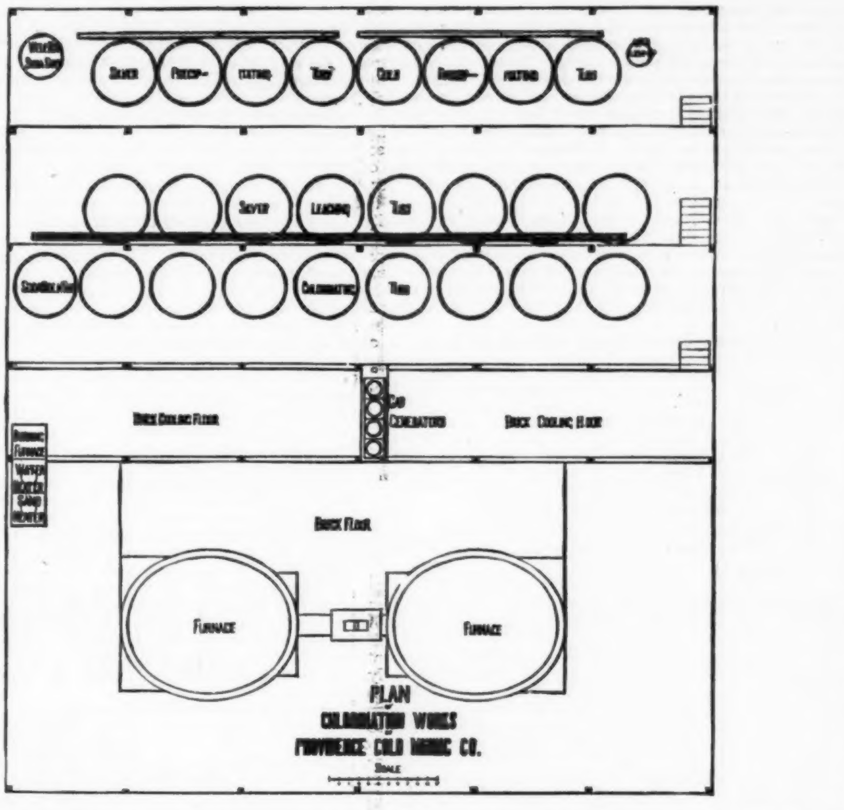
ROASTING FURNACE OF PROVIDENCE CHLORINATION MILL.

* The value of these is said to be $120 in gold and $12 in silver per ton.

* For a more detailed account of the reactions taking place in roasting, the reader is referred to *The Leaching of Ores of Gold and Silver*, Aaron, 1884.

* The reader is again referred to Aaron's work on leaching for a more detailed account of the reactions in lixiviation, but it must be admitted that many important questions as to solubilities and other points connected with leaching are not as yet answered in technical literature, and that much analytical investigation remains to be made.

The ore, deprived of its gold, is left to drain for 24 hours in the chlorination tubs; then it is shoveled into another set of similar tubs, and pure water is run through the mass until the soluble salts of the base metals are well washed out, which is the case when the water coming from the ore gives but a slight precipitate on being tested with a solution of the polysulphide of lime. The ore is then allowed further time to drain thoroughly, and thereupon is leached with the solution of hyposulphite of calcium (or calcic thiosulphate, CaS_2O_3).



For this operation the leaching tubs should be kept full of the solution, and the outflow regulated to suit the capacity of the precipitating tanks, the solution pump, etc. The leaching is continued till the solution from the tubs gives but a trace of precipitated sulphide of silver, when a little calcium polysulphide is added to it in a test glass. This condition is reached in a few hours in treating this particular ore, but two or three days are required to leach some silver ores.

The silver solution having been run into tanks, is precipitated with a solution of calcium polysulphide. Great care is exercised in avoiding the use of an excess of the precipitant, for this would subsequently be carried back into the silver leaching tubs together with the solution of calcium hyposulphite, and would there precipitate silver as a sulphide, which would inevitably be lost. It is always safer to leave a little silver in the hyposulphite solution, for there it is not lost, while furnishing sure evidence that no excess of the precipitant has been used. To detect such excess, take in a test glass some of the clear solution, from which the sulphide of silver has settled, and add to it a little dilute acetate of lead. This reagent will produce a precipitate of sulphide of lead if a trace of calcium polysulphide is present. If an excess is found, more of the silver solution must be run into the precipitating tank.

The heavy sulphide of silver settles in an hour or two, leaving a clear solution of calcium hyposulphite, which is drawn off into a well, and pumped from there up into a distributing tank for subsequent leaching. The sulphide of silver is cleaned out of the precipitated tanks as often as necessary, and is put into a cloth strainer from which the solution drains off. The sulphide, after drying, is burned in a small reverberatory furnace; the silver is then melted in graphite crucibles, with scrap iron for a flux, and is finally run into bars.

The residue or tailings in the silver leaching tubs, after having been deprived of all mineral of economic value, are discarded. It is claimed that by this process 94 per cent. of the gold and 60 per cent. of the silver are saved.

PREPARATION OF REAGENTS.

Chlorine Gas.—This gas is generated in lead vats, 22 inches in diameter and 8 inches deep, set in brick work over a flue which is warmed to about 90° F. The vats are provided with lead covers having two openings, each 1 inch in diameter, into which lead pipes are luted with flour dough. One of these pipes serves for conducting off the gas; the other for introducing sulphuric acid. The second pipe is so bent as to form a trap just above the cover to prevent the escape of gas.

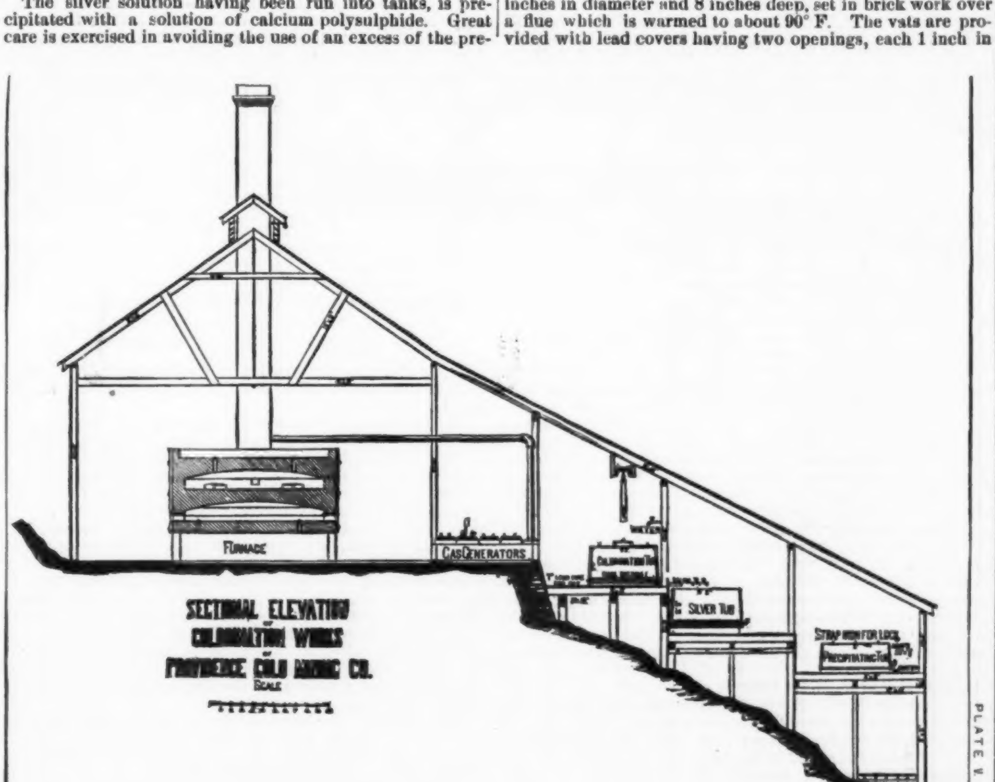
Into each generator are charged 9 pounds of black oxide of manganese and 11 pounds of common salt; then the cover is luted on with flour dough, and the sulphuric acid is run in. Commercial sulphuric acid of 66° B. density is diluted with water in the proportion of 16 measures of acid to three of water, and 9½ quarts of this solution are used for each generator. The acid is placed in a convenient lead vessel above the generator, and by means of a faucet is allowed to pass drop by drop through the trapped lead pipe into the same. In this way the gas is slowly evolved, at about the rate that it can be absorbed by the ore in the tubs. From the generator the gas passes by one of the lead pipes through a pan of water into a glass bell-jar inverted in the water bath, and thence by a rubber hose, attached to a nipple on top of the bell-jar, to the chlorinating tubs. Two of these generators furnish in 12 hours enough gas for one tub, or for 2½ tons of ore.

Sulphate of Iron.—This precipitant is made by dissolving iron scrap in very dilute sulphuric acid—30 gallons of water to 1 of sulphuric acid. An excess of iron is used.

Calcium Hyposulphite.—This solvent is not prepared directly; the solution for leaching chloride of silver is first made of sodium hyposulphite by dissolving the crystallized salt in water, making a solution of 3° B. density. By the leaching operation a soluble hyposulphite of silver and sodium is formed. When calcium polysulphide is added to this to precipitate the silver, calcium replaces silver in the solution. The double salt of calcium and sodium so formed is used as a solvent in the next leaching operation, and in the subsequent precipitation more calcium enters the solution. Thus the proportion of calcium to sodium increases until the solvent becomes practically the hyposulphite of calcium, which is equally effective in forming a soluble double salt with silver chloride.

The use of iron pipes or of an iron pump for this solution should be avoided, as iron is readily attacked by it. Brass should be used instead.

Calcium Polysulphide.—This is made by boiling powdered sulphur and quicklime in water. Into a 100-gallon tub are run 56 gallons of water; when boiling, 35 pounds of lime are added, and then 15 pounds of sulphur; the boiling is maintained for 5 hours with live steam, and the bath is kept well stirred.



THE MILL.

General Design.—The stamp mill is shown in sectional elevation on Plate I. Special attention is called to the framework of the building, and to the uses which it serves in supporting machinery and shafting. The ore bin, C, furnishes a foundation for the rock breakers, B, and grizzlies, A, as well as for the entire upper part of the building. The counter shaft, T, and the concentrator shafts, L, L, are supported on the roof trusses, while the main line shaft, K, rests on the battery frames.

Sizing Grates.—The mill is furnished with two sizing grates, or grizzlies, corresponding to two rock breakers. Each grizzly is 4 feet wide and 12 feet long, made of iron bars 4 inches deep and 1 inch wide, set 2¼ inches apart and held in place by five 1 inch rods passing through them horizontally, with ferrules on the rods between the bars. The rise of the grizzly is 6 feet 3 inches, which is not very great. The upper end is covered for a length of 4 feet with an iron plate upon which the ore is dumped.

Rock Breakers.—The two rock breakers are of the latest Blake patent, with 10 inch jaws. Each breaker can crush 50 tons of ore in twelve hours.

Ore Bin.—The ore bin is a plain rectangular chamber extending the whole length of the mill behind the batteries. It is 13 feet wide and 11 feet high, and is inclosed by a heavy frame lined with 2 inch planks. The typical inclined back is left out, and the ore is allowed to form its own slope on which it will run; thus the space which generally contains nothing but expensive framework and lumber in most mills is here occupied by a reserve pile of ore.

Automatic Feeders.—Each stamp battery is served by a Hendy automatic feeder, indicated at D. This apparatus is made by Joshua Hendy of San Francisco, and costs $250.

Stamp Batteries.—The batteries have heavy square frames, which are the best form for this kind of mill. Being very rigid, they serve excellently for supporting the line shaft; they also form a most convenient platform upon which to roll the cam shafts when it becomes necessary to remove them; and, more important still, they leave the space about the mortars unobstructed. Complete working drawings of the battery frames are given on Plates II. and III.

The battery screens are No. 5, of the heaviest Russia iron that can be punched. They last about four weeks by reversing.

The mortars weigh 6,000 pounds each.

The weight of a stamp complete is..	750	pounds.
The weight of a shoe is....	125	"
The weight of a die is............ ..	95	"
Shoes of chilled cast iron last.......	30 to 35	days.
Dies of chilled cast iron last.......	45 to 65	"
Steel shoes last....................	90	"

As the steel shoes cost 11 cents per pound, and shoes of cast iron 4½ cents, there is not much choice between the two kinds.

The battery blocks shown in the drawings are 10 feet long and set upon rock bottom. Dry blankets are spread on top of these blocks to form a cushion for the mortar.

Amalgamators.—The aprons in front of the batteries are the full width of the mortars and 4 feet long. They are covered with silvered copper plates, and incline 1¾ inches in 1 foot. Beyond each apron there are two sluices, shown at F; each is 16 inches wide and 14 feet long, covered in the same way as the aprons and having the same inclination. From these sluices the ore slime, or pulp, is carried through launders to the concentrators, G, G.

At the lower ends, or tails, both of the aprons and sluices, there are cross troughs, fitted, as shown, with longitudinal dividing boards, which extend to within two inches of the bottom. As the pulp runs into these troughs it has to pass under the dividing board, and in so doing drops the particles of mercury and amalgam which it carries in suspension.

Concentrators.—There are two concentrators for each battery of five stamps, or 16 in all for the 40 stamp mill. These machines are the latest form of Frue vanner, and cost $750 each in San Francisco.

Motive Power and Water.—The whole mill is run by a six foot hurdy gurdy wheel, the invention of Pelton, of Nevada City. The wheel is driven with 104 inches of water* under a pressure due to a 390 foot head. The water costs 16 cents per inch, so that the motive power to run the mill for 24 hours costs $16.64. It would require 12 cords of wood to furnish the same amount of power. In the batteries, on the concentrators, and in the chlorination works 5 inches of water are used and 1 inch is wasted, making altogether 110 inches which the company buys.

Shafting.—The main line shaft is driven by belting, with two pulleys interposed, from the water wheel. This shaft is supported on the square battery frames, as represented on

* An inch of water flowing 24 hours amounts to 17,000 gallons.

"Plan of Top Frame," Plate III., and drives the whole mill, including 2 rock breakers, 40 stamps, and 16 concentrators. It is composed of five sections, as shown in Plate IV. in detail. Attention is directed to the form of coupling used, with a projecting collar on the one half fitting into a recess in the other. This device serves to keep the shaft in line if the bolts should not fit the holes in the coupling perfectly; but the same result can be secured by allowing one section of shaft to protrude half an inch, while the other is half an inch short in its part of the coupling, and this form is preferred by some.

Eeach coupling must be keyed solidly to its shaft, which is then put into a lathe and the coupling faced off perfectly true.

Each section of ten stamps is driven from a friction pulley on the line shaft. These are iron pulleys with a friction clutch, which serves to throw off any section of stamps at pleasure without stopping the balance of the mill.

The main driving pulley and the cam shaft pulleys are of wood. For pulleys of such large size they are cheaper than if made of iron, and they serve as well. The wooden pulleys are all turned up on the shaft in position.

There are four cam shafts, each driving ten stamps. They are 5 inches in diameter, and each is driven by a 14 inch rubber belt.

The rock breaker shaft, T, is $2\frac{7}{8}$ inches in diameter, and is driven from the main line shaft by a 12 inch rubber belt. Each rock breaker is driven from this counter shaft by a 6 inch rubber belt.

There are two concentrator shafts running the whole length of the mill, each $1\frac{7}{8}$ inches in diameter. The one nearest the main line shaft is driven from that shaft by a 6 inch rubber belt, and the two concentrator shafts are connected by a 6 inch rubber belt as shown in Plate I. Each concentrator is driven from its corresponding shaft by a 3 inch rubber belt.

The size of every pulley and its speed are indicated on the general drawing, Plate I.

Cost of Milling.—The mill is so arranged that hand labor is reduced to a minimum. Eight men suffice to run the mill day and night and keep it in repair. They are distributed as follows: two men by day, and one at night, spall the rock and feed the crushers; three men by day, and two at night, take care of the batteries, tend the concentrators, and deliver the concentrates into the drying room. The immediate daily running expense then would approximate the following:

3 Men at rock breakers	@ $2.25	$6.75
3 " batteries	@ 2.25	6.75
1 Man at concentrators	@ 2.50	2.50
1 Foreman	@ 3.50	3.50
110 Inches water	@ 16	17.60
Wear on shoes		6.11
" dies		3.42
" screens		3.87
" rock breakers, " concentrators, " copper plates		5.00
Illuminating		1.00
Lubricating		1.00
Total		$57.50

The average quantity of ore milled per month is 1,850 tons, or 62 tons per day, which brings the cost for milling and concentrating to about 93 cents per ton.

THE CHLORINATION WORKS.

General Design.—The general plan and side elevation, Plate V., show the arrangement of the chlorination works, as well as the frame of the building itself. The floor upon which the sulphurets are dumped when first brought from the drying room of the stamp mill is not shown, but it is level with the top of the roasting furnaces.

Furnaces.—There are two roasting furnaces, placed as shown on the general plan, and provided with a double flue chimney. The details of their construction are shown in working drawings on Plate VI.*

These furnaces are built entirely of common red brick, and after two years' constant use they are in good condition. The "Plan of Top" shows the surface on which the ore is first spread to dry and heat. The walls of the furnace extend 10 inches above this level, forming a shallow basin. The ore is passed from one hearth to the next one below through ports four inches square, of which there are two in the upper floor, one in the second floor, and four for discharging the ore from the furnace. Each of these ports has a countersunk top, into which is set an iron plug, fitted with a handle for its ready removal. The lower hearth is supported on arches, as shown in "Section through A B." Under these arches the hot ore, as discharged from the furnace, is left to cool. The second hearth is provided with three working doors, and the lower one with four; all of these are arranged with a view to convenience in stirring the ore, and to reaching without difficulty every part of the hearths.

The flame spreads well over the lower hearth; the hot gases passing thence to the second hearth, by two flues shown on "Plan of Second Hearth," are turned in direction, and escape through the chimney.

The walls of the furnace are 13 inches thick, and are held securely in place by iron bands and staves. The brick wall is first encircled by three bands of $4\times\frac{1}{2}$ inch flat-iron, each band consisting of four sections, which are drawn together by $\frac{3}{4}$ inch bolts; then 32 vertical staves of 1×3 inch bar iron are set around the wall, as shown; and these are held in place by three outer bands of $4\times\frac{5}{8}$ inch iron. Each of these bands likewise consists of four sections, drawn together by $1\frac{1}{2}$ inch bolts, which have a right-handed thread cut on one end and a left-handed one on the other, with a square section in the middle. The ends of the outer bands are bent to form rectangular loops, which are closed completely by welding, as seen in the drawings. The bolts are screwed into nuts placed in these loops.

The working doors are 17 inches wide and 8 inches high at the outside of the wall, but enlarged inward to allow a greater range for the hoe in stirring. In the doorway is set a cast iron frame $\frac{1}{2}$ inch thick, to which the door is hung.

Chlorination Tubs.—These are of peculiar construction Their capacity is $2\frac{1}{2}$ tons each, and they have the following dimensions:

Diameter at top	5 feet 9 inches.
" " bottom	6 " 3 "
Depth to false bottom	3 " 6 "

The bottoms are made of 3 inch planks tongued together. The staves are of 2 inch stuff with plain joints, but there is a batten $\frac{3}{4}$ by $2\frac{1}{2}$ inches over each joint, and there are four iron hoops around all, driven hard. This construction gives a tight tub, and saves the iron hoops from being corroded by the chlorine, as would be the case if they fitted closely to the staves. The cover is made of $1\frac{1}{2}$ inch stuff tongued together, and stiffened by four cleats screwed on top. A jog is cut all around the top of the tub $1\frac{1}{2}$ inches deep and one inch from the inside of the staves; the cover fits into this jog, leaving a clearance of 1 inch for calking and luting. An iron bail is bolted to two cleats of the cover, to serve for raising it with the aid of a tackle, indicated on Plate V. The latter hangs from a small truck which travels on a suspended track extending over the whole row of tubs. The tubs are provided with false bottoms made of 1 inch boards perforated with inch holes, and covered with a double thickness of gunny sacks. They are supported two or three inches above the bottom by cross pieces.

Leaching and Precipitating Tubs.—The silver leaching tubs are of substantially the same construction as the tubs for chlorination, and the precipitating tanks differ only in being a little shallower, but there is no reason for having them so. All the tubs are painted inside and out with three coats of liquid asphaltum varnish, which should be renewed every year.

Output, Labor, Fuel, and Cost.—The maximum capacity of the two furnaces is 9 tons of sulphurets in 24 hours. Each furnace burns 1 cord of wood in 24 hours, and requires two Chinamen to work it during that time—the same man tending the whole furnace. Another Chinaman, one white man, and the foreman complete the force for the chlorination works.

The immediate daily expense then would be about as follows:

1 Foreman	$3 00
1 White laborer	2 25
5 Chinamen, at $1.50	7 50
2 Cords wood, at $5.00	10 00
29 lb. binoxide manganese, at $2\frac{3}{4}$ cts.	80
260 lb. salt, at 1 ct	2 60
216 lb. sulphuric acid, at 2 cts.	4 32
Lime, sulphur, and calcium hyposulphite	30
Illuminating	20
Extras	1 00
Total	$31 97

This outlay makes the cost of treatment per ton of sulphurets amount to $3.55, when the works are run at full capacity.

But the ore contains, as has been stated, about 7 per cent. of sulphurets, or $4\frac{1}{3}$ tons in the 62 tons milled daily. Though this quantity of sulphurets does not keep the two furnaces running at full capacity, yet both of them are maintained in continual operation. Most of the expenses remain the same, whether treating this smaller amount or running at a full 9 ton capacity; the actual cost, therefore, figured on a working basis of $4\frac{1}{3}$ tons daily capacity, approximates as follows:

Labor	$12 75
2 Cords wood at $5.00	10 00
14 lb. binoxide manganese at $2\frac{3}{4}$ cts.	38
126 lb. salt at 1 ct.	1 26
104 lb. sulphuric acid at 2 cts.	2 08
Lime, sulphur, and calcium hyposulphite	15
Illuminating	20
Extras	50
Total per day	$27 32
Adding to this the cost for milling per day	57 50
The total outlay per day equals	$84 82

or $1.37 per ton for extracting the gold and silver from the ore. This estimate makes no allowance for the expenses of general supervision, interest on first cost, and gradual deterioration.

* For these excellent drawings I am indebted to Mr. W. H. Englebright, Surveyor in Nevada City.

SCARLET FEVER IN NORWAY.

A VALUABLE contribution to epidemiological literature has been made by Dr. Axel Johannsen in his monograph on the "Epidemic Prevalence of Scarlet Fever in Norway" (Christiania, Jacob Dybwad, 1884), in which he has spared no pains to investigate the subject in a thorough manner. He has succeeded in obtaining records of epidemics which occurred so far back as 1817, and in each year from 1825 to 1878 inclusive, the latter years comprising naturally more full and exact details than the earlier ones. From the facts thus gathered he has compiled a series of statistical tables which tell of the great labor expended on his task. A number of diagrams are also appended, showing the relative distribution of the disease in proportion to the population in the different districts, and curves of the prevalence and mortality of scarlet fever as compared with those of other infectious diseases. It would be impossible to give here any but the barest review of some of the data which he has obtained. Among these may be mentioned the fact that 42 per cent. of the epidemics occur in the autumn months—September, October, and November—the smallest number of cases occurring in spring and summer. In the twelve years 1867 to 1878, there were attacked with scarlet fever 6,278 adults, or 9·8 per cent., and 57,982 children (under fifteen years of age), or 90·2 cent., the cases being about equally distributed between the sexes. Speaking of the mortality from the disease, he points out that it is one of the main causes of death in the country, the rate varying from 2·12 per cent. to 12·5 per cent of all persons attacked, epidemics varying much in their degree of severity. In children the mortality in the twelve years above mentioned was 16·6 per cent.; in adults 3·8 per cent.; among males 17·5 per cent; among females 15·2 per cent. He compares the mortality in town and country districts, showing that it is proportionally higher in the latter. He discusses the question of incubation, of recurrences, and second attacks, and then deals in turn with each of the complications of the fever—angina, nephritis (extremely variable in different epidemics), phlegmonous inflammation of the neck, parotitis, arthritis, affections of the respiratory and digestive organs, of the sensory organs, of the brain, and pyæmia, gangrene, and noma. He states that Koren records in the Christiania epidemic of 1875–77 twenty-seven cases of scarlatinal arthritis out of 426 patients, the joints of the hand, fingers, and knee being most affected; it was invariably a simple serous synovitis. Pneumonia was not a frequent although an unfavorable complication. Meningitis was a frequent occurrence in the stage of evasion in the epidemic in Solor-Odalen in 1875–77. As to otitis, Koren found that in the Norwegian deaf and dumb institutes 12·38 per cent. of the deaf-mutes owed their defect to scarlet fever. Some doubt is thrown upon the occurrence of true scarlet fever in puerperal women, but the author does not discuss this question at length. His statement that, out of 146 deaths in childbed in the years 1874–78, only three were due to scarlet fever seems to support his contention. The monograph, it may be added, is written in the German language. From the large mass of material which the author has collected the facts deduced are reliable, and will doubtless be utilized by subsequent writers on the subject. We should like to see a similar exhaustive study made of epidemic disease in this country; but we fear that until we have a thorough system of registration such a work could never be completed.—*Lancet.*

A RAMROD IN THE BRAIN.—RECOVERY.

By Geo. Fischer (*Deutsche Zeitschrift f. Chirurgie*) the following unparalleled case in surgical literature is related: At a shooting festival in Hanover, it occurred that a carbine was unexpectedly discharged, from which the ramrod had not been drawn. The ramrod struck a man in the back, was driven through the neck and head, from which it projected. The man reeled, staggered, but did not fall. He was laid down; he remained motionless and speechless. A comrade tried to draw the rod out, he used enough force to raise the body from the ground, but without success. Other attempts were made to that end, so much so as to drag the body over the ground, but failed. He had nausea and vomiting, but finally answered questions rationally.

Four hours later he was in the hospital. The obtuse end of an iron rod, thirty centm. long, projected on the left side, over the foreman supraorbitale. The integuments grasped tightly the rod; not a drop of blood escaped. On the right side of the neck, below the angle of right submaxilla, was a great hard and painful swelling. Nothing abnormal could be felt in the throat. Between the right scapula and the vertebral column in the region of the fourth dorsal vertebra was a gunshot wound of the size of a five cent piece, with black edges; the patient could stand up, was weak, apathetic, but could give rational answers, and remembered distinctly the whole occurrence. The pupils were dilated, sight not very good, bleeding from right nostril, breathing normal, pulse rhythmic, sixty. The ramrods of carbines have a large button on one end; and as these rods are very short, the button end must necessarily be embedded in the neck. Without an anæsthetic, the wound was enlarged, and the button end of the rod was discovered up in the region of the sterno-cleido-mastoideus. The larger vessels were not seen. The rod was firmly wedged in the cranium, so that in order to loosen it the bones had to be chiseled away around it, and by many blows of a hammer it had to be driven downward before it could be extracted. No bleeding.

The patient was perfectly cognizant of what was going on, and made many sensible observations. He lay absolutely motionless, while, with a hammer, the rod was driven down. The operation lasted one hour. The rod was fifty centm. long, the lower end six mm., the upper seven mm. thick. The button had a circumference of four centm.

Cerebral symptoms were only trivial, first those of concussion, late of compression of the brain, memory little impaired. Escape of cerebro-spinal fluid in the right nostril. Amaurosis of right eye, suppuration of right ear, temperature a little higher, frequency of pulse, slow respiration, digestion, micturition not disturbed. The length of gun shot canal was thirty-five centm.

In order to ascertain the probable injury of the various organs and tissues, Prof. Henle of Göttingen imitated the canal on a cadaver. He found: The ramrod after penetrating the back between the M. splenius cervicis and M. levator scapulæ without injuring the cavity of the chest, before the vena jugularis int. and art. carotis communis, near the bifurcation, behind the M. sterno-cleido mastoid, behind the belly of the M. stylo hyoid, and stylo-glossus; immediately behind the posterior margin of the median root of the pterygoid processes the ramrod entered the cranial cavity. It penetrated to the right sphenoid fossa, the lower floor of the orbital cavity, went through the right canalis opticus, lacerated the optic nerve. Here it struck the right gyrus, went then a distance between both hemispheres to the left side of the falx cerebri, then through both gyri fornicati up, three c.m. long through the left gyrus frontalis superior, and through the os frontalis ant.

After nine weeks patient left the hospital cured, after eleven months was perfectly well, attended to his very laborious duties, and dances all night as often as he can; amaurosis continues.—*St. Louis Med. and Surg. Journal.*

MOBILITY OF THE BRAIN.

THE paper recently read before the Academie de Medecine by M. Luys cannot fail to be of great interest to the physiologist.

The cerebral mass, he says, inclosed in the cranial cavity is surrounded by an empty space which permits its displacement in different attitudes of the body, and enables it to obey the laws of gravity. When a man is placed in an inverted position, the forehead being on a horizontal plane, the cerebrum glides from before backward; in the vertical position it always obeys the laws of its weight, recedes from the cranial vault, and leaves an unoccupied space at the vault. In a position of lateral decubitus the lower lobe sinks down and the upper presses upon it, slightly displacing the falx cerebri. In this position the vacant space is between the temporal lobes and the skull. Luys' experiments enable him to state that the gliding movement of the cerebral mass takes place in an automatic manner; that this movement does not take place suddenly, and that five or six minutes are required for the displaced part to regain its normal situation.

This mobility (or locomobility, as Luys terms it) of the brain should, from a physiological point of view, have a considerable influence in the phenomena of cerebral life. In the vertical position the brain, in pressing upon itself, causes a certain degree of folding in the compressed parts. Hence we notice various ischæmic troubles in debilitated subjects who have been confined in bed for some length of time; and that syncopal state known as sunstroke, which often takes place during a prolonged vertical position; and the various phenomena—vertigo, titubations, loss of consciousness, etc.—which depend upon arrest of the circulation in the basal capillaries. So true is this that the empirical remedy, horizontalizing the patient, is one which nature always employs in order that the pressure upon the capillaries may be removed and the circulation re-established.

It is very probable that this automatic displacement may have a large influence in the causation of sea-sickness. The rapid succession of tosses experienced by the cerebral mass should be expected to contribute largely to the development of that curious state of nausea and cerebral malaise; and it

is well known that the horizontal position will tend to relieve it. Even during the period of diurnal activity, the head being in the erect position, the locomobility of the brain should, by reason of its keeping that organ in one position, and by the constant moving about of the body, subjecting it to a series of slight tosses or jars, cause a fatigue *sui generis* analogous to that felt by other organs. In the domain of pathology this phenomenon must necessarily play an important part. When the meninges become inflamed, thus interfering with the gliding movements of the brain, we at once see an array of very intense symptoms. Persons with cardiac affections, or subject to frequent congestions of the encephalon, often experience marked relief from the vertigo and other symptoms by change of position. Cerebral troubles, apoplexy, etc., are more frequent in the morning, when the subjects suddenly assume the erect position. It is well known that nocturnal attacks of epilepsy may frequently be arrested by placing the sufferer in the erect position; and that nervous subjects who see disagreeable objects while lying down may be relieved by assuming an erect or reclining position.

At each expiratory movement there is an ebbing of the venous current toward the capillaries, so that when expiratory movements succeed each other rapidly, the cerebral mass is literally projected upward against the cranial vault. This explains the mechanism of certain cases of cephalalgia, especially that seen in infants with grave diseases. On the other hand, the concussions produced by an external cause, the repeated shocks during a long carriage ride, for example, are known to cause cerebral fatigue, and often nausea. In young and healthy subjects this is not of especial moment; but in subjects of cerebral congestions, or hemorrhages, or softening, great damage may be done by a short journey, especially if the journey be rough. When these patients are compelled to travel, the distance journeyed each day should be as short as possible, and so arranged that the patient may be able to rest during the afternoon and night.—*Medical Record.*

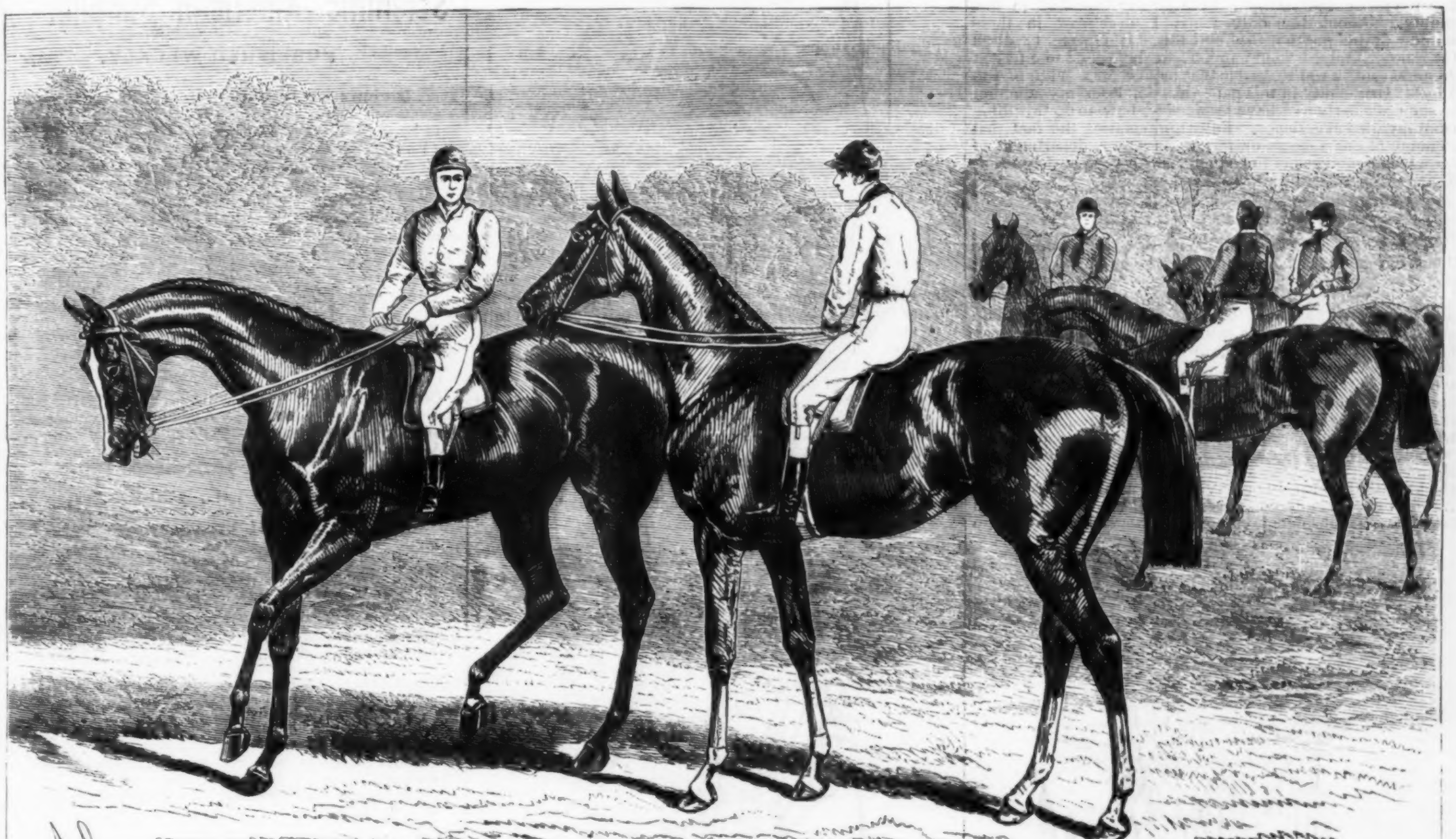
THE DERBY.

THE two horses, Harvester and St. Gatien, which lately came in together at the race for the Derby, are represented in our illustration.

Harvester, by Sterling, the dam Wheatear, ran six times in the colors of his late owner, Lord Falmouth, as a two-year-old, being successful on two occasions. He made his first appearance at the Newmarket July Meeting, when he finished second to Superba for the Chesterfield Stakes, but he was unplaced to Duke of Richmond, Brest, and Serge II. in the Richmond Stakes at Goodwood, while he was among the beaten lot in the Rous Memorial Stakes, won by Superba. At the Newmarket First October Meeting he scored a victory in the Thirty-sixth Triennial Produce Stakes, beating Knight Errant, Kinfauns, and six others, and this feat he followed up by taking the Clearwell Stakes at the Newmarket Second October Meeting, but he suffered defeat in the Dewhurst Plate, which was won by Queen Adelaide, Busybody finishing second, Fritz third, and Talisman fourth.

He commenced his three-year-old career by carrying Sir J. Willoughby's colors into third place for the Two Thousand at the Newmarket First Spring Meeting, Scot Free and St. Medard occupying first and second places, and subsequently won the Payne Stakes, in which he beat Scot Free, Brest, and three others.

St. Gatien, by Rotherill or the Rover, the dam St. Editha, ran three times last year, being successful on each occasion, his first victory being achieved in the Teddington Two-Year-Old Plate, at the Kempton Park May Meeting. At the Manchester Summer Meeting he took the John o' Gaunt Plate, and won the Little John Plate at the Nottingham Spring Meeting.—*Illustrated London News.*



HARVESTER AND ST. GATIEN—WINNERS OF THE DERBY.

HOW TO LAY A DRAIN.

By J. M. ALLEN.

IN taking up this subject I shall only undertake to deal with that part of the question relating to practical and thorough execution of the work of drain lines. The first want is to know the amount of fall in each 100 feet throughout the length of the drain. This is best determined by a practical engineer with a railroad level. Do not let him proceed in the ordinary way, driving pegs fifty or a hundred feet and furnishing you a profile on paper, number and depth at each peg. His instrument will likely be correct, but his individual calculations of depth at each peg is not near so likely to be so. Let engineer and attendant take a chain 100 feet long, drive a peg at outlet to start with, marking it 0; draw chain tight, drive a peg marked 1, 2, and so on until the number of chains are found in the whole line. Suppose the line is 2,200 feet long and the fall is 44 inches, or 2 inches to the 100 feet. This is about the fall ordinarily found in level land in my locality. Suppose we have an outlet of 4 feet, and it is desired to lay the line four feet deep at the upper end with a uniform fall throughout. Then let attendant take a stake of 18 or 20 inches long with a square end, and drive as straight as may be by the side of the last peg at the upper end, so that the top will be just 12 inches above the surface of the ground. Now place the rod on the top of the peg and move the target on the rod until it falls in line of sight from the level, and note result. Now let attendant take a similar stake and pass down the line 200 feet, and drive it down beside the peg numbered at that point. Drive the stake down until the line of sight from the level will strike the rod standing on top of the stake just four inches higher than at the upper stake. Drive stakes down at intervals of 200 feet, knocking them in the ground so that the line of sight from the level will strike the rod standing on the tops of stakes just four inches higher at each succeeding stake until the outlet is reached. Now the tops of the last line of stakes will represent a grade line just five feet above the bottom of the drain, with a uniform fall of 2 inches to the 100 feet throughout. I have purposely selected a fall of 2 inches to the 100 feet because it gives a simple illustration of the method of procedure. Where the fall is ascertained to be inches and fractions of an inch, read the fractions in hundredths. If you commence setting the grade stakes at the outlet 200 feet apart, then the line of sight must strike the rod standing on the top of the grade peg at twice the number of inches and hundredths of an inch 100 feet lower on the rod at each succeeding 200 foot peg. This idea of leveling a ditch I got a few years ago of D. R. Jacobs, of Pancoastberg. I believe it is his custom to drive grade stakes every 100 feet, driving them so that their tops are just 6 feet above the bottom of the drain. The above method of leveling a ditch can be done by any ordinary intelligent farmer who is able to adjust a level whether he has any book education or not, thereby knocking about all the professional out of the business, a thing always to be desired on the farm, where price is considered. The next thing needed will be ten or a dozen stakes with a cross piece nailed on the top in the form of a "T." The cross pieces should be about a foot long, and the stakes they are nailed to of different lengths, from 16 inches to 3 feet or more. These being procured, go to the first stake at the outlet and drive one of these "T" stakes so that the top bar will be just on a level with top of the grade peg. Go up the drain to the next grade stake, 200 feet, and drive another in the same manner, until the top bar is just level with the top of the grade stake. Go below the outlet and drive two more "T" stakes, 10 to 30 feet apart, any distance apart that will suit your convenience. Drive them down until top bars of the Ts are in exact range with the top bars of the two stakes driven above, and you are in shape to go digging. In regard to spades, I prefer an 18 inch, thin, steel blade, concave, round point and a D handle. This length of blade will enable you to cut 4 feet 4 inches at three cuts. I always use a line to mark by, and find a cord about ⅛ of an inch thick about the right size. It should be 60 to 100 feet long. Make the lining very accurate, as any crooks on the top will only be intensified as the drain is sunk down, making the tile lying in the bottom full of little short wiggles; impairing its efficiency by the increased friction of the water on its walls. It will not discharge near as much water as a straight laid drain of the same sized caliber of tiles, the fall and depth being equal. A common long handled spade with a light steel blade is a preferable tool to do this lining, and a long handled round pointed shovel to throw out the crumbs after the first cut. For the second cut you will need a narrower shovel for all the smaller sizes of tiles. For a 4 to 5 foot ditch the top should be about 14 inches wide and sloped down both sides alike to just admit the size of tile used. Cut the first spade some rods up the drain, then go back to the outlet and cut a second spade up that far. If you have used an 18 inch spade, one cut more will sink the drain to the bottom. You will now want a long handled bottoming scoop with the blade standing at such an angle from the handle that it will rest flat on the bottom while you are standing on the bottom of the second cut, 18 inches above the bottom the tiles are to be placed on. Take your spade and cut about 4 feet up the drain from the outlet, throwing the earth on the bank. Take your scoop and clean the crumbs out. You will now want a light and rather stanch measuring rod just five feet long. A piece of cane fishing pole, such as the boys use, makes the lightest and best rod I have used. Stand the rod on end in the ditch; see, by sighting over the top of it, that it is just in range of the top bars of the two "T" stakes driven beyond the outlet that we described before. If the rod stands higher than the bars, place your thumb nail against the rod and at right angles with it; slide your thumb down the rod until it is in line with the tops of the bars, and the distance from your thumb to the top of the rod will represent the depth to be dressed off of the bottom. After this is done stand the rod in the ditch again, and if the top of the rod is in range with the tops of the bars below, standing at any point along the four feet you have cut, the grade that far is perfect and you are in shape to lay three or four tiles. A little practice with this thing will enable you to strike the proper grade levels very readily. Procure a piece of tin or sheet iron large enough to close the end of the tile. If the water is running in the ditch, punch the tin full of holes. An eight penny nail, a block of wood, and a hammer are all the tools needed for this. Lay the tile with the joints close as you can, shut the end of the last tile laid with the tin. Cut from the sides of the drain at a point where the best clay is found enough dirt to cover the tile. Step out on the tile, placing your feet on each side of them and close to the banks, and tramp down firmly. Now take your spade and cut about four feet more, pitching the dirt down the drain on the tiles laid. Finish grade with bottoming scoop and rod as before. Pull up your tin, and you are in shape to lay three or four tiles more. Proceed in this manner until the whole line is completed. Use the remaining "T" stakes by driving them down in the dirt on top of the tiles opposite each grade peg with the top bars just level with the tops of the grade pegs as you pass them. This method of digging leaves nearly one-third of the dirt excavated on the tiles in the ditch where you want it. It never gets out on the bank to be put back. This enables you to put the dirt from the

first two cuts very near the edge of the bank, and is easily put back with either plow, scraper, or shovel. It also makes a remarkable small showing of dirt on the surface for the depth excavated. This plan of laying tiles, so far as I am able to judge, gives at least 20 per cent. better results than the way I used to do it by excavating the whole line and laying the tile from the upper end and down stream. The banks will cave in more or less. The water and air soften the bottom, and tramping up and down the drain to clear obstructions would get the bottom in such a shape that it would be impossible to get a perfect grade with the most careful man I have ever yet seen in a ditch. If the land is full of water and no danger from frost, it is best to cut the whole line one spade deep and the second spade up quite a distance so the water will drain out. This will greatly lessen the danger of the banks caving in. If the soil is too hard to work with a spade, get a bar of round iron one and a quarter inches in diameter, take it to a good blacksmith, have the end split and five or six inches of the best cast steel welded in. Finish at the point in the form of the chisel 1½ inch wide with the bevel all on one side and as long a slope as the steel will bear. Temper as a drill for stone. This iron bar or spud should be just five feet long when finished, and can be used to determine the grade by sighting over the top same as your cane measuring rod. This tool will be found much superior to the common pick with eye and handle like a mattock, which, if there were water in the ditch, would splash you terribly, and if the ditch is 4½ to 5 feet deep, would have to be made wide enough to admit your shoulders so you could swing the pick. This bar will enable you to carry the depth of 18 inches right along through the hardest clay, so you can grade and lay the tile same as when you were using the spade. I prefer the depth of four feet if the outlet will possibly admit of it. The unequalities of the land will then make the depth 4 to 5 feet. I know that many farmers prefer 2 to 3 foot drains to deeper ones. I question both the durability and efficiency of such work, and fear that too many shallow drains have already been laid in this county. About the only merit I ever saw in these shallow drains was that they cost less. If I were to ditch for wages simply, I would prefer to lay tiles 2 to 3 feet at 25 or 30 cents a rod to double that money for a depth of 4 to 5 feet. Originality in this paper has not been my aim, but to state as clearly as I have been able, how to do this thing from my own experience. Fully appreciating the fact that so much of our success or failure in every department of farm business depends so largely on *knowing just how to do things*.—*Drainage and Farm Journal.*

ORNAMENTAL GRASSES.

WE have often some difficulty in reconciling ourselves to the use of grasses as decorative subjects either for the lawn, the flower border, or the shrubbery. Many of them are looked upon as weeds, and doubtless weeds they are from a florist's point of view, but it is also true that some of those grasses now never seen in a garden are worthy of being there for dinner table decoration, to which they would add as much grace as costly exotics. We are far from being in sympathy with those who grow nothing but beautiful flowering plants to the exclusion of those having graceful foliage or feathery heads of various forms and hues, and which, when properly managed, give quite as subtropical an appearance to mixed borders, etc., as do castor-oil plants, solanums, and many others more difficult to manage. Until recently, the beautiful feathery headed pampas grass and its varieties were seldom seen, even in the best of gardens, and now few are considered complete or too small to have a

FESTUCA ELATIOR.

clump of them. Among others, plants of Arundo, Bamboo, Arundinaria, etc., with their peculiar reed-like habits and modes of growth may be introduced with advantage into shady sheltered nooks, many of which are always to be found in gardens. These plants adapt themselves to the positions indicated admirably, at least in the neighborhood of London, and even when grown in pots, sheltered during winter in a cool outhouse or shed, and plunged in the open about the end of April or beginning of May, the transformation would be at once agreeable and advantageous. Most of the other grasses, with the exception of the Eulalias, and of course those just mentioned, are strictly herbaceous, dying down in winter, and giving more facility for covering or protecting them from severe frosts or a superfluity of water, the latter being as damaging in its results as the former. Some of the Panicums, also, such as P. bulbosum, P. capillare, Erianthus Ravennæ, Polypogons, Stipa gigantea, S. pennata (the Feather grass), etc., are all very useful, together with many others equally interesting. Some of the dwarfer sorts, among them the Quaking grass (Briza media), Poas, and Agrostis, are useful, and might be employed with

BROMUS INERMIS.

very great advantage in the making of bouquets, wreaths, etc., as they can be dried, and when that is done carefully they may be had nearly as fresh looking six months after as when cut. The annexed engravings represent three of the many grasses that could with advantage be utilized in one or all of the several ways just enumerated.

Festuca elatior is a native of Britain, where it is found growing in moist meadows and Osier grounds. It is of perennial duration, varying in height from 3 feet to 6 feet. Its leaves are nearly twice the size of those of F. pratensis, from which, moreover, it also differs in having drooping panicles spreading loosely and gracefully in all directions, with sharply pointed oval and less flat spikelets, and having the

ARRHENATHERUM AVENACEUM.

florets frequently awned, and in the case of strong growing specimens faintly ribbed. It is to all appearance admirably suited to a moist, clayey soil, in which it is well worth cultivating for its ornamental character. F. flabellata, a fine, strong growing species, often forms dense tufts from 5 feet to 6 feet in height. In the matter of fragrance few, if any, can vie with our sweet vernal grass (Anthoxanthum), Hierochloa borealis, and some of the Andropogons.

Arrhenatherum avenaceum, or Avena elatior (the Oat grass), is also found wild in this country, frequently in bushy places on roadsides and by hedges. It is of perennial duration, and generally forms bulbs or swollen joints, one directly above the other, from which it throws out innumerable runners, which assist greatly its capability of standing much drought. It grows about 3 feet in height. The flowers, which are produced about the end of June, are very pretty, and conspicuous from a distance. It forms long spikes of fine feathery appearance, and should be on every lawn, either isolated or in company with the above.

Bromus inermis is a native of Germany and the south of Europe generally. It is one of the few Brome grasses that can be used with advantage for ornamental purposes. It grows from 2 feet to 3 feet high, and bears erect panicles, wide spreading and slightly drooping, and furnished with nearly beardless imbricated florets. The leaves are long, narrow, and smooth to the touch. It is a perennial, and flowers from June to August. It should be grown in wet places near the margins of lakes or swamps. Aira cæspitosa is also a native of our shores, and one of the tallest growing of British grasses; it is perennial, and flowers profusely in June and July. It grows from 3 feet to 4 feet in height; the leaves are very narrow and rough at the edges. The panicles are large, much branched, and of a silvery gray color; the florets have long hairs at the base, which give them quite a unique appearance. There is also a viviparous variety of it in which the awn is inserted above the middle of the valve, and another having small panicles of pretty purple florets; both are very interesting, and should find a place in every pleasure garden or lawn, both on account of their peculiar and ornamental characters.—*D. K., in The Garden.*

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